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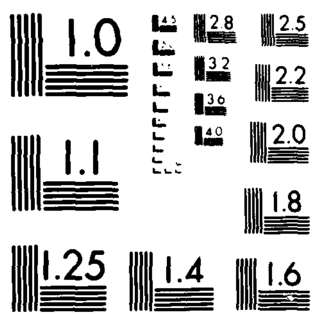

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AD-A133 673

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LOGISTICS STUDIES OFFICE

PROJECT NUMBER 028

FINAL REPORT

METHODOLOGY AND CRITERIA FOR ACCURATELY DETERMINING LOGISTICS ASSISTANCE MANPOWER REQUIREMENTS

SEPTEMBER 1982

U. S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
LOGISTICS STUDIES OFFICE
FORT LEE, VIRGINIA 23801

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The views, opinions, and/or findings contained in this report are those of the author and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

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This study investigates the process used within the Logistics Assistance Program to generate requirements for Field Maintenance Technicians. The complexity and lack of visibility of present procedures have called into question the validity and accuracy of current requirements. Moreover, each of the DARCOM Major Subordinate Commands has its own Field Maintenance Technician staffing pattern and requirements determination method. The major recommendations of this study are that centralized staffing guides be prepared and that

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SEPTEMBER 1982

Letter on file

DR. GERALD S. GARFINKEL

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ABSTRACT

This study investigates the process used within the Logistics Assistance Program to generate requirements for Field Maintenance Technicians. The complexity and lack of visibility of present procedures have called into question the validity and accuracy of current requirements. Moreover, each of the DARCOM Major Subordinate Commands has its own Field Maintenance Technician staffing pattern and requirements determination method. The major recommendations of this study are that centralized staffing guides be prepared and that technical assistance requirements be considered within the Integrated Logistics Support concept for weapon and equipment systems.

Report Title: Methodology and Criteria for Accurately Determining Logistics Assistance Manpower Requirements

Study Number: LSO 028

Study Sponsor: US Army Materiel Development and Readiness Command
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EXECUTIVE SUMMARY

1. <u>Background</u>.

a. The Logistics Assistance Program (LAP) aids Army units in the field by supplying them with highly trained, mostly civilian, workers called Field Maintenance Technicians (FMT). Each Major Subordinate Command (MSC) maintains its own workforce of FMTs who are expert at maintaining and supporting the systems supplied by that MSC. At many installations, a Logistics Assistance Office (LAO) staffed by DARCOM personnel coordinates requests for FMT assistance and acts as a liaison between the installation and the LAP.

b. Annually each MSC determines how many FMTs will be needed for training or assistance at each Army installation. This determination is then reviewed or revised at the installation sub-LAO level, at the Major Army Command (MACOM) and MACOM-LAO level, at DARCOM and finally at Department of Army level.

c. Recently there have been differences of opinion among these levels as to what the true needs are. Also there have been situations in which specified manpower needs were not filled and the impact on field unit readiness standards has not been identified. Thus, a need has been recognized for a method to accurately and credibly determine manpower requirements for LAP.

2. <u>Objective</u>. To develop criteria and credible models or methods with which the Major Subordinate Commands and MACOMs can project Field Maintenance Technician requirements for the Logistics Assistance Program.

3. <u>Limits and Scope</u>.

a. The study analyzes requirements for Field Maintenance Technicians only and does not analyze requirements for the other major classes of Logistics Assistance Program personnel--Field Supply Technicians, Logistics Management Specialists, administrators, clerks.

b. Needs of LAP users such as Active Army and Reserve Component/National Guard units and LAP providers such as DARCOM and MSCs are considered.

c. This study does not consider possible manpower requirements during mobilization or wartime periods.

4. Methodology.

a. Data for this study came from literature searches, interviews, and documents furnished by the study sponsor. Examination of LAP regulations and related studies were helpful. Many interviews were conducted with LAP personnel and users at the study sponsor's office, at MACOM and sub-LAOs, and at LAP workshops.

b. Statistical regression analysis was performed on some of the numerical data using the BASIS statistical analysis software on the Burroughs 6800 computer.

5. Findings and Conclusions (references are to the Main Report and Appendices).

a. Findings.

(1) There is no historic data base of FMT requirements, fills, and specialties (Paragraph VD1).

(2) The Major Subordinate Commands have very different methods to determine FMT requirements (Paragraph VB2).

(3) The present requirements determination system involves many groups, each estimating requirements and is thus very complicated and often confusing (Paragraphs VB1c, VC1).

(4) Recent projections have often been repetitions of current requirements. The special needs of many major systems scheduled for deployment have not been adequately addressed (Paragraphs VC2, VC5, and Appendices B, C, D).

(5) Specific Logistics Assistance Program assets and requirements are often omitted in the Integrated Logistics Support planning for major systems (Paragraph VD2).

(6) Many FMT requirements, especially OCONUS, remain unfilled (Paragraph VC4).

(7) A frequent complaint that FMTs spend too much time on supply matters appeared in interviews with users, FMTs and Logistics Assistance Office personnel, and in various previous studies of LAP (Paragraph VC3).

b. Conclusions.

(1) Predictive and accurate regression models for FMT requirements cannot be produced because sufficient data is unavailable (Paragraph VD1).

(2) MSCs need to use a more widely understood and centralized methodology to determine requirements (Paragraph VD3).

(3) Present staffing patterns show that MSCs differ in degree of FMT specialization and in the basis for FMT manyears--density of equipment, complexity of equipment, or number of force units equipped (Paragraph VB3).

(4) The present LAP policy of providing long term support to various major weapon/equipment systems is justified. Institution of a policy to terminate FMT requirements for systems deployed two years or longer is unrealistic (Paragraph VA3 and Appendix A).

6. <u>Recommendations</u> (references are to the Main Report and Appendices).

a. For each supported system, the MSCs should prepare a Support Formula indicating how many FMTs are needed to support the system at particular types of installations or force units. The Support Formula could be in the form of a staffing guide. It would be preferable to have it embedded in a support plan which would include realistic projections of the Support Formula and information on the supported system and FMT skills and performances (Paragraph VD3, Appendix J).

b. Logistics Assistance Program requirements should be included in Integrated Logistics Support (ILS) plans. To accomplish this the following changes should be made (Paragraph VD2).

(1) Include technical assistance as an element of ILS in AR 700-127.

(2) Specify in MIL-STD 1388 that all weapon system and equipment support analysis to determine manpower, personnel, and training needs should consider the requirements and resources of LAP and other sources of technical assistance.

(3) DARCOM Circular 700-9-4 should instruct that materiel fielding plans estimate specific quantities and types of technical assistance required to field a new system.

c. A priority system for filling FMT requirements should be formulated. Such a system could be user generated or be based on the operational readiness criteria or amount of equipment usage (Paragraph VC4, Appendix F).

d. The problem of possible excessive supply work for FMTs should be researched. It should be determined if the problem is real and whether it comes from unrealistic expectations of the users, inadequate supply training of the FMTs, inadequate attention from the Logistics Management Specialists in the LAOs, inadequate numbers of Field Supply Technicians from the MSCs, or still other causes (Paragraph VC3).

MAIN REPORT

I. Background.

A. Each commander is responsible for developing and maintaining a logistics support capability. However, the Army recognizes that problems--especially with respect to new or modified equipment and support systems--often arise which cannot be solved with the resources available to the local unit commander. Thus, the Logistics Assistance Program (LAP) is the DARCOM effort to assist Army field units solve problems concerning maintenance, supply, and operation of weapon and equipment systems.

B. LAP personnel operate out of Logistics Assistance Offices (LAO) which are located at major Army installations, units, and command posts. These personnel basically divide into two classes. Assigned to the LAO are the LAO chief and a staff of Logistics Management Specialists, all of whom work directly for DARCOM. These people coordinate activities of the other staff and help Army personnel with general supply, maintenance, and operation problems involving DARCOM equipment and systems. More specialized assistance is provided by Field Maintenance Technicians (FMT) and Field Supply Technicians (FST). This class of LAO personnel work for the various Major Subordinate Commands (MSC) of DARCOM and are considered as attached, rather than assigned, to an LAO.

C. FMTs assist users with maintenance, supply, and operation of equipment and weapon systems supplied by their MSCs. Their assistance includes providing both formal and on-the-job training, helping in various troubleshooting efforts, correcting and often expediting important requisitions, informing users of upcoming modifications and product improvement programs, finding technical fixes to unique local equipment problems and relaying back to the MSC unexpected problems arising in the fielding of equipment.

D. Determining the necessary FMT manpower requirements has become a serious problem. The present lengthy determination process, involving the MSCs, MACOMs, installation commands, MACOM and installation level LAOs and DARCOM, has exposed various disagreements, often of a basic philosophical nature, among the participants. The credibility of the stated requirements is weakened by the existence of a large group of unfilled requirements--in particular up to 50% of total requirements for certain MSCs in Europe. Another important aspect of the problem is the expansion of the determination process to include the requirements which will be generated by the vast numbers of new systems coming into the Army inventory.

II. Objective. To develop criteria and credible models or methods with which the Major Subordinate Commands and MACOMs can project Field Maintenance Technician requirements for the Logistics Assistance Program.

III. Limits and Scope.

A. The study will analyze requirements for Field Maintenance Technicians only and will not analyze requirements for the other major classes of Logistics Assistance Program personnel--Field Supply Technicians, Logistics Management Specialists, administrators, clerks.

B. Needs of LAP users such as Acti Army and Reserve Component/National Guard units and providers such as DARCOM and its MSCs will be considered.

C. This study will not consider possible manpower requirements during mobilization or wartime periods.

IV. Methodology.

A. Data for this study came from literature searches, interviews, and written documents from the study sponsor. Examination of the official regulations governing the Logistics Assistance Program and of various previous studies of

LAP were useful. Many interviews were conducted with LAP personnel and users. These interviews were at the study sponsor's office, at MACOM and sub-LAOs, and at LAP workshops.

B. Statistical regression analysis was performed on some of the numerical data. The BASIS statistical analysis package on the Burroughs 6800 Computer System at Fort Lee, Virginia, was useful in carrying out the regression analysis.

V. Analysis and Discussion.

A. Literature search.

1. There are two types of written material on the Logistics Assistance Program that relate to determining FMT requirements. First, there are the official regulations that set up the general framework of the program. Second, there have been in the last 10 years a number of studies of the program--some of which are related to the manpower requirements within the program.

2. Regulations governing LAP:

a. Department of Defense (DOD) Directive 1130.2.

(1) DOD Directive 1130.2, dated 18 June 1979, gives general DOD guidance for the "Management and Control of Engineering and Technical Services." The directive states[1]:

> "The introduction of new equipment and systems requires the transfer of technical knowledge from producer to DOD personnel or user...until the user is capable of maintaining and operating the equipment and systems. ...In order for DOD components to achieve in-house self-sufficiency, the following services shall be available to them.
>
> 1. ...Contract plant services.
> 2. ...DOD engineering and technical service specialists.
> 3. ...Field service representatives.
> 4. Contract field services."

(2) Two other parts of the Directive are relevant to this study. First, "requirements for ... DOD engineering and technical services specialists... shall be reviewed annually at Military Department...headquarters level to: ...

Assess the achievements of military readiness...(and) Identify requirements related to immediate needs and to the updated Five Year Force Structure...." Second, "a single office at the headquarters level of Military Departments... shall ensure that requirements represent valid needs."

b. AR 700-4, updated on 1 January 1980, "establishes Department of the Army (DA) policies for providing logistic assistance" and "implements DOD Directive 1130.2." The regulation states[2] the objective of "Assisting commanders in resolving those logistical problems on materiel readiness which are their responsibility, but are beyond their capability to resolve with organic resources." It states, however, that the commander still "is responsible for developing a self-sustaining capability. (However) this capability is not an authorization for a major field commander to develop an assistance program that replaces the mission responsibilities in this regulation." Another main objective stated is to provide logistics information to DARCOM and its Major Subordinate Commands (MSC) with the aim of "improving materiel and its logistic support."

(1) The regulation states "DARCOM provides, manages, and controls a worldwide logistic assistance program (and) determines, establishes, staffs, and maintains LAOs."

(2) It also states "The providing command will - (1) Determine the most suitable assignment method (i.e., temporary duty (TDY) or permanent change of station (PCS)). (2) Assure personnel...have current knowledge and broad experience.... (3) Establish a rotational base."

(3) The chapter on Logistics Assistance Requirements states "The providing command, in close coordination with the supported commands, will develop LAP manpower requirements each fiscal year on a 3-year basis." It then states that manpower requirements will be based on:

"(1) Types, numbers, priorities and geographic dispersion of using and support units.

(2) Authorized levels of organization, mission, and readiness postures.

(3) Amount of equipment...on-hand or scheduled for deployment....

(4) Complexity of weapon or equipment systems.

(5) Reliability, availability, and maintainability of weapon and equipment systems.

(6) Scheduled deployment...of new and modified...systems and redistribution of older...systems....

(7) ...providing logistics information feedback.

(8) Materiel fielding plans, project handoff and providing command consideration such as training and rotation base.

(9) Projected availability of trained personnel from TRADOC.

(10) Actions by supported commands to provide training."

(4) The chapter goes on to state that the MRC has to send MACOM coordinated requirements to DARCOM. DARCOM will return DA approved requirements to the MRC and the MRC will give preliminary and final FMT fill data to the MACOMs and DARCOM. Other sections authorize short-term or emergency assistance requests and state the minimal information to be included in requests for assistance. It is not specified whether these "requests for assistance," in Section 4-3, are the emergency and short-term ones referred to in Section 4-2 or are major system support requests which would justify the MRC total FMT manpower requirements packages.

c. DARCOM Regulation 700-100 implements AR 700-4. It specifies that the technically oriented personnel will be provided by the Materiel Readiness Commands (MRC). Their personnel are "attached" to an LAO. They are to be supervised by MRC personnel but can be tasked by the LAO chief. On manpower requirements DARCOM Regulation 700-100 states[3], "The MRCs are responsible to

initiate action for the determination of logistics assistance manpower requirements. MRCs will coordinate initial estimated requirements with the appropriate MACOM LAOs and the supported commands." MRCs are to send estimates of requirements for three fiscal years to MACOM LAO with information copies to the MACOM. The MACOM LAO in turn sends the requirement to the subordinate LAO chief who with the local MRC representatives is to obtain user approval. The package is then sent back to the MACOM LAO chief who coordinates MACOM approval and sends it back to the MRC. The MRC, after perhaps adjusting and coordinating changes, sends the final package to DARCOM who then reviews it and forwards it to DA.

3. Previous studies.

a. The Bryant and Miletich 1973 study[4] was a broad based examination of the management, organization, personnel and effectiveness of the Logistics Assistance Program. It was conducted mainly by surveying and interviewing individuals within LAP and those who used LAP services. The study did not deal specifically with the requirements determination process. However, some of the points it raised also surfaced in the course of conducting the present study. Two such findings are the heavy reliance of users on FMT support in the supply area and on the continuing need for LAP support "because of the complexity of equipment in the field, the shortage of adequately trained support troops, and the rapid turnover of user unit personnel."

b. The Ortman and Edmondson 1977 study[5] was a follow-up of the Bryant and Miletich study. Many of the questions on their survey forms were the same as those in the previous study. Of course their survey forms were sent to and filled out by a different set of individuals. As might be expected, the authors reaffirmed many of the findings of the previous study. Much of the data gathered by the authors was used as evidence in statistic tests of hypotheses arising from the previous study.

c. Beauchamp Study (1978).

(1) In 1978 COL Darwin Beauchamp, the LAO Chief at HQ FORSCOM, provided a study[6] of FMT requirements throughout FORSCOM. The rationale for producing this study was given as follows:

> "HQ FORSCOM has enunciated a policy which requires the supported commands to reduce reliance upon DARCOM technical assistance and develop their own organic capability. In consonance with that policy, FORSCOM DCSLOG and LAO personnel have jointly reviewed and reduced the FY 79 FMT requirements. The picture which emerged from this effort has motivated this study."

Among the purposes of the study was a desire to demonstrate that "the current situation is characterized by an overall excess of FMTs and generally disproportionate distribution among FORSCOM stations" and "to offer a simple, logical technique for the determination of valid, basic requirements."

(2) The method developed was first to assign to each station a given FMT requirement based on the type of major unit (heavy division, airborne division, infantry brigade, etc.) at the station. Then these total requirements were redistributed based on certain numerical factors derived from adding together unit factors based on total troop strength, amount of MSC equipment, and the number of types of MSC equipment deployed. These modified requirements, the current requirements and a relative operational readiness rating measure were then used to derive final requirements. A detailed description of the method is given in Appendix G.

(3) The Beauchamp study concluded that, first, the current FMT requirements were too high and, second, the current FMT requirements were badly distributed among the FORSCOM stations. An analysis of the Beauchamp determination method shows that the total final requirements must be close to the total of originally assigned unit-type requirements. Since the latter total was substantially less than the total of current requirement, the Beauchamp first conclusion was an inevitable

consequence of the assumptions and methods and was unrelated to the numerical or operational readiness factors employed. The evidence for the second conclusion is much stronger. However, the giving of equal weight to troop strength, equipment quantity, and equipment complexity is questionable. A regression analysis, described in Appendix G, shows that for most MSC the FMT distribution mostly followed one of the three factors, not an average of all three. Thus perhaps the maldistribution conclusion was a consequence of trying to impose one uniform calculation method on five different types of MSC patterns.

d. Byrne-Gray Study.

(1) In 1977 the Direct Logistics Support (DLS) concept was tested at Fort Hood, Texas. The DLS concept involved reorganizing the LAOs into DARCOM Logistics Assistance Activities (DLAA). Each DLAA would give direct logistics assistance to a division, corps or other major unit and would consist of a DLAA chief and a team of DARCOM Logistics Management Specialists (LMS) and FMTs from the MSCs. Special cells of team members might also be organized to assist on certain types of equipment, e.g., tanks or aircraft. As part of the evaluation of the DLS concept, DARCOM was asked to produce DLAA staffing guides. In response to this request, Mr. Francis M. Byrne and Mr. W. Bruce Gray of the DARCOM office that produces staffing guides for various DARCOM activities produced an in-house study[7] entitled "Field Maintenance Technician Staffing Formulas."

(2) The authors state that "the thrust of this study is to...develop standards for determining manpower requirements that are logical, valid, and acceptable. To accomplish this, a line-by-line analysis of estimated MRC requirements was made for three levels of effort...:

(a) Full dedicated staffing under the original DLS concept.

(b) Minimum essential staffing obtained by pooling various skills at higher echelons.

(c) Current staffing."

Although analysis of three levels of effort are mentioned, the draft report only has an analysis of the current staffing patterns.

(3) Essentially by scrutinizing the FY 78 requirements, Byrne and Gray arrived at guides as to how many FMTs from each MRC are needed to support each of the following:

OCONUS Division

CONUS Division

OCONUS Corps

CONUS Corps

MACOM

ADA or PERSHING Battalion

TRADOC Center with FORSCOM Brigade or Regiment

They also produced yardsticks that related FMT support requirements for tanks and helicopters to the number of tanks or helicopters being supported. The linear relation between numbers of helicopters and supporting FMTs is further developed in Appendices E and F of the present study. This analysis supports the existence of strong correlation between helicopter numbers and aviation FMT requirements. However, analysis of Beauchamp's data in Appendix G of this study shows that TACOM FMT requirements are more strongly correlated with total troop strengths than with density of tanks. FY 78 requirements which did not fit the staffing formulas were labelled "additional efforts." Much of the MICOM and CECOM requirements were so labelled.

B. <u>Present Requirements</u>.

1. <u>General Determination Process</u>.

a. The present FMT requirements determination process is very lengthy and involves many participants. The present procedure, with slight modifications,

has been in operation since 1979. However, it has not always been followed (see Appendix C), and there is the possibility it may soon be changed to give greater weight to MACOM opinions about requirements.

b. Each MSC initiates the process by filling out a DARCOM Form 2560-R indicating for each duty station, by specialty if appropriate, the present requirements and fill and the projected requirements for each of the three upcoming fiscal years. By 1 October the appropriate package is sent to each MACOM LAO. The MACOM LAO sends the requirements projection for each installation or major subcommand to the associated sub-LAO. The sub-LAO then coordinates the package with the user and by 15 November returns the coordinated package to the MACOM LAO. The latter then coordinates the total MACOM package with its associated MACOM and returns the package by 1 January to the MSC. The MSC then makes any changes it deems necessary, coordinates these changes with the MACOMs, and sends a final package to DARCOM (DRCRE-FLA) by 1 February. DARCOM refers back any discrepancies to the MSC for reconciliation and submits the fully reconciled package to HQDA for approval. When HQDA sends DARCOM the approved requirements, they are then forwarded to the MSCs and MACOM LAOs. By 1 August the MSC informs the MACOM and MACOM LAO of the projected fill for the approved requirements.

c. Installation LAP personnel--e.g., the LAO chief or the leader of an MSC team of FMTs--sometimes view the locally generated requirements as official. Of course, the official requirement is the MSC/MACOM coordinated and DA approved estimate.

2. <u>Specific MSC Procedures</u>.

a. The MSCs have different approaches to determining requirements for FMTs. They have different methods of initiating their determination process. Some have only requirements for generalists, others only for specialists. Some

manage to fill almost all their requirements; others have many unfilled requirements. In the next few paragraphs the approaches of the separate MSCs are summarized.

b. The MICOM requirements are initially determined by the Land Combat and Air Defense branch chiefs in the Field Service Activity (FSA) division at Redstone Arsenal. Thus, the intensity of support for each system is mostly uniform--e.g., each HAWK battalion will receive approximately the same number of FMTs. All MICOM requirements are for experts in a specific missile or a small group of missiles. Mostly, MICOM will require a given number of FMTs for each major unit deploying a specific missile system--e.g., three FMTs for each HAWK battalion. The number of FMTs assigned per unit changes year by year as the perceived need changes. (See for example Appendix C describing USAREUR FMT requirements). Some of the factors influencing these requirements are scheduled Product Improvement Program modifications, improved Reliability, Availability, Maintainability (RAM) statistics, and other historical experiences with the system. As of FY 1981 almost all of the MICOM requirements were filled.

c. CECOM.

(1) The CECOM requirements determination process is the most complex. First, the process is decentralized. For example, the requirements for Forts Hood, Carson, and Riley are initially determined by the area supervisor at Fort Hood. They are then reviewed by the CECOM regional office at HQ FORSCOM and finally sent to HQ CECOM at Fort Monmouth. These requirements are then sent to the MACOM LAOs as the initial CECOM requirements projection package.

(2) One advantage of CECOM's method is that requirements are determined very close to the user level. Conversely, a problem with this decentralized method is that the amount of support per system is very variable and it is difficult for

someone outside of CECOM to understand why a specific system needs differing amounts of support at different locations. Even the types and descriptions of requirements differ from region to region. For FORSCOM, a simple rule accounts for most CECOM requirements--namely, one FMT each for STANO (radar and other vision enhancing devices), avionics, general communications and ADP. However, no such simple rule seems to describe the overseas requirements.

d. TACOM and ARRCOM theoretically have no specialists; all the FMTs can support any of the equipment from their MSC. In practice there is some specialization, e.g., one ARRCOM position is mostly used to support the VULCAN gun, and one TACOM position is in support of construction equipment. In each MSC the determination process is initiated at the FSA level. Most of the requirements are static and the determination process has mainly led to the current requirements becoming the projected requirements. (See Appendices B, C, and D on the various MACOM FMT requirements). However, this situation of static generalist requirements at TACOM and ARRCOM may soon change. With new systems such as the M1 Abrams Tank, the M2/M3 Fighting Vehicle Systems and the DIVADS Artillery coming into production, both MSCs are considering the option of supporting these systems with specialists, at least during a period of initial deployment.

e. TSARCOM requirements are determined at the FSA HQ. The FY 81 requirements and projections of FY 82 through FY 84 requirements are nearly identical. The FMTs are mostly specialists. The aviation FMTs specialize in one or more types of aircraft or in turbine engine maintenance. The ground support FMTs mostly specialize in maintaining power generators or general soldier support type equipment.

3. <u>Present Staffing Patterns</u>.

a. Determination methods and the resulting requirements and fills in the various MACOMs are fully explained in Appendices B, C, and D. In this section the data from those appendices are summarized and analyzed.

b. Table 1 summarizes the FMT requirements by MSC and force unit supported. The TSARCOM requirements are also classified into aviation and ground support requirements. Using the results from Appendix E, one can recompute the TSARCOM requirements as those for ground support (as indicated in Table 1) plus .019 times the number of aircraft to be supported.

c. MICOM requirements cannot easily be summarized by force unit supported since they mainly depend on the number and type of specialized units, usually battalion size, deploying each type of Army missile. The USAREUR and CONUS requirements for each of the MICOM specialties are summarized in Table 2. Note that units in Europe tend to have slightly greater requirements, mainly due to the geographic isolation and dispersion of the units. The most dramatic example of this situation is in the distribution of TOW-DRAGON requirements. In CONUS most divisions have one FMT, otherwise known as a Missile Maintenance Technician (MMT), who supports both the Land Combat Support System (LCSS) equipment and the TOW-DRAGON system. In Europe each TOW-DRAGON battalion has two or three MMTs assigned and each division also has a TOW-DRAGON MMT expert.

d. The figures in Tables 1 and 2 account for almost all of the MICOM, ARRCOM, TACOM, and TSARCOM aviation support. About 15% of the CONUS support is given to unique specialized units and is not reflected in these tables. The TSARCOM aviation requirements in CONUS are fairly accurately computed by the formula ".019 times number of aircraft supported." Since the number of aircraft supported at the European locations at the different maintenance levels is not clear, the above formula may not accurately compute the USAREUR aviation requirement.

TABLE 1

OVERALL PRESENT FMT STAFFING

		CORPS	DIV	CBT BDE	ADA BDE	ACC BDE	ACR	TRADOC
E	CECOM	7	5.5	1.5	4	0	1.5	-
U	TACOM	4	3.0	1.0	0	0	1.0	-
R	ARRCOM	3	3.0	1.0	0	0	2.0	-
O	TSARCOM	0	3.5	1.0	1	0	2.5	-
P	GROUND	0	1.2	1.0	1	0	1.0	-
E								
C	CECOM	?	5.0	1.5	2	2	1.0	.5
O	TACOM	0	3.0	1.0	1	0	2.0	1
N	ARRCCM	0	2.5	0.6	.5	.5	1.5	.5
U	TSARCOM	1	6.0	2.0	1	4.3	1.5	.5
S	GROUND	1	2.0	0.7	1	1.0	0.5	.5

TABLE 2

MICOM MMTs

	PERSH	LANCE	MLRS	LCSS	TOWD	TOWC	HELLF	HERCL	CFRS	TSQ73
EUROPE	2	.5	C	.5	2.5	1	2.5	1	A	A
CONUS	2	.5	C	.5	0.5	1	2.0	-	B	B

A - One MMT supports one or two battalions
B - One MMT supports a division
C - System not deployed, support transitioning to two per unit

C. Weaknesses in Present Method.

1. Confusing Procedures - The diversity of MSC determination methods and the large number of different groups involved in FMT requirements determination contribute to confusion and loss of credibility within the determination system. The MSCs differ widely on the methods of requirements computation used, on the prevalent staffing patterns developed and on the subgroup of the FSA organization responsible for initially determining FMT requirements. One result is that individuals outside of an MSC (and sometimes even inside the MSC) do not understand how the MSC generates its FMT requirements. These requirements would be more credible if their methods of determination were better known. A related problem is that with so many groups reviewing and making their own estimates of FMT requirements, some individuals in these groups are confused as to what the finally recognized requirements are.

2. Requirements Projections - One of the major rationales for the Logistics Assistance Program is the assistance given to field units in the initial years of new equipment deployment. Indeed during the next few years many new Army systems are scheduled for deployment. However, except for MICOM, very few of the projected requirements seem to reflect the need for support to these new systems. As can be seen in the MACOM requirements, Appendices B through D, most of the requirements projections have been almost completely static.

3. Supply Assistance Requirements - Although requirements for the supply experts, the Field Supply Technicians (FST) are included with the FMT requirements, the two sets of requirements are not well integrated. A substantial portion of the typical FMT workload involves assisting with requisition requests. The Ortman and Edmundson study reports[5] on page 56 that a 1977 survey of selected Army units indicated 35% of their LAP requests were for supply assistance. The Bryant and Miletich study[4] found

(pages 131-132) that "most all installations and organizations express a desire for more supply assistance." In interviews conducted by the present study author at Fort Hood and Fort Bliss, many individuals inside and outside the LAP stated there was a need for more FSTs. One FMT group leader claimed his people spent 60% of their effort on supply problems and that these problems could more effectively be handled by Field Supply Technicians. Many people claim FMTs do too much supply assistance and that they waste time on "parts-chasing." Nevertheless, it seems that a larger number of FSTs would be useful and that a more realistic combination of FMT/FST requirements would be very useful.

4. Unfilled requirements - The relatively large number of unfilled requirements, especially in Europe, weakens the credibility of the present requirements. An MSC leaving a stated requirement unfilled for many years may be an indication that the MSC does not view the requirement as legitimate or at least as not very important. Also if a requirement is unfilled without a drastic effect on readiness, perhaps it is not "required" after all. If an MSC does not have enough personnel or funding to fill all its requirements, how does it decide which ones will go unfilled? Appendix F relating aviation requirements to readiness and usage indicates a readiness driven process might be feasible in deciding the question of which requirements should have higher fill priority. Of course, some other priority determination system, such as user supplied priority, could also be used.

5. Tailoring LA efforts to specific systems.

a. A major rationale for the Logistics Assistance Program is to provide support for complex Army weapon and equipment systems. Therefore, a clear and uniform plan of support for such systems is desirable. However, at present there are few such support plans.

b. Currently the MICOM, the TSARCOM aviation, and much of the CECOM effort is tied to support of specific systems. Although theoretically all ARRCOM and TACOM FMTs can support all the systems supplied by their MSC, in practice many specialize in one or more systems and, informally at least, expend most of their effort in supporting these special systems. Both ARRCOM and TACOM are considering supporting some of the major new Army systems by officially designated FMT specialists.

c. Only MICOM and the CONUS TSARCOM aviation support efforts are clearly uniform throughout each MACOM. MICOM is also the only MSC that frequently changes its system support intensity in response to changing system characteristics such as years of deployment, upcoming major modifications, improved RAM data. Most of the other MSC support efforts, at least as reflected in requirements projections, are unchanging, even when major new systems are scheduled for deployment.

D. Possible Improvements.

1. Developing Regression Models.

a. One of the major objectives of this study is to provide better methods of determining FMT manpower requirements. Originally, study effort was directed toward implementing this objective by developing regression models of manpower requirements.

b. It was anticipated that for each FMT classification, regression analysis of the historical relation between previous manpower requirements and values of the important work-related data variables would result in predictions of future manpower needs. However, it was discovered that there was no good historical data on FMT specialty requirements at duty stations. Moreover, the historical data that was available is suspect since one of the main problems

in the program is the credibility of the stated requirements. Still another problem in the predictive model approach is that both TACOM and ARRCOM are considering using dedicated FMT support for some of their new systems, but almost all of their recent support has been with general nondedicated support. Thus, there cannot be in these cases any historic base upon which to project future needs.

c. The most available and accurate data was that describing the current and projected requirements from FY 81. Most of the "projections" were simply a restatement of "current" requirements. Thus, this data clearly was not very useful for predictive purposes. However, it is somewhat useful in testing whether present requirements are credible. In particular, the regression analysis was performed on the FY 1981 requirements with the aim of finding underlying staffing patterns. In many cases, reasonable such patterns were uncovered. See Paragraph B3 on Present Staffing Patterns and Appendices B through G.

d. Since predictive models could not be developed, effort was instead concentrated on developing methods to make the determination process more visible and thus more credible. One of the benefits from implementing the recommendation to produce a LAP System Support Plan is that a historical data base would be developed. Then at a future time, predictive regression models could likely be developed to project FMT manpower requirements.

2. Include LAP within Integrated Logistics Support.

a. Inclusion of LAP support requirements with the Integrated Logistics Support (ILS) concept may be an effective and visible method of associating LAP efforts with support of specific major systems. Since LAP is widely acknowledged to be a major component of the total support system for major weapon and equipment systems, it would be appropriate to identify LAP explicitly as an ILS element.

b. The DARCOM Pamphlet, AMCP 706-132, Maintenance Engineering Techniques[8] specifies that detailed technical assistance requirements be included in the development plans for a new weapon/equipment system during the conceptual, validation, and full scale development phases. Since the 1975 publication of this pamphlet, system development has been placed under Integrated Logistics Support. Neither the current nor the proposed revision of Army Regulation 700-127, Integrated Logistics Support[9] mention FMTs or LAP. There are only two mentions of technical assistance. First the Materiel Fielding Team (MFT) and its subordinate New Equipment Training Team (NETT) are described as offering new equipment introduction briefings and unit personnel training as needed. Second, the material developer may offer to the gaining command a statement of support for the 60-day initial fielding period. This statement may include provision for technical assistance.

c. Materiel Fielding Plans.

(1) DARCOM Circular 700-9-4. A major component of ILS is the Materiel Fielding Plan (MFP) in which the materiel developer describes the new weapon or equipment system, details how the system will initially be fielded, and specifies the responsibilities of the parties involved in the fielding. DARCOM Circular 700-9-4, Logistics Instructions for Materiel Fielding,[10] has only one reference to technical assistance. In the section on Personnel and Training, the circular instructs that in regard to technical assistance personnel the MFP should state "what assistance will be provided for locally conducted training and on-the-job training (other than New Equipment Training)."

(2) Technical Assistance in Materiel Fielding. Materiel Fielding Plans usually mention the need for technical assistance without specifying the exact type and quantity of support necessary. The actual requirements are negotiated annually among the Project Manager (PM), the supporting MSC and the

using MACOM. MSC and PM policies with regard to technical assistance vary. Two examples follow:

(a) The Bradley Fighting Vehicle System (FVS) is a new system scheduled for deployment to Europe. Its PM has an agreement with the MSCs that at each fielding site one ARRCOM, one MICOM, and two TACOM FMTs will be available. These FMTs do not necessarily have to be stationed at these sites. They could be on call at some central location. The MSCs have the responsibility of ensuring that properly trained FMTs will be available. The PM is funding these FMTs during the first year of fielding. The MFP for the Bradley FVS is, however, not very specific. It states[11] that FMTs will assist the PM in resolving problems during initial fielding, assist field units during and subsequent to fielding and "will be the agent for all technical assistance to POMCUS and CEGE sites." Also, in three places it mentions the need for FMTs to be trained on the Bradley systems. It does not provide any quantitative estimates of requirements.

(b) Another example is the HAWK missile system, which has been deployed in Europe for many years, but has frequently had Product Improvement Programs and other major modifications impacting on its operation and maintenance characteristics. MICOM negotiates its HAWK FMT support with both the HAWK PM and the USAREUR user. Consideration is given to both the PM scheduled modifications and the Operational Readiness ratings of the deploying units. However, MICOM's policy is to provide the same amount of support to each HAWK unit and thus to consider total HAWK readiness rather than the readiness ratings of each individual unit.

d. Logistics Support Analysis. ILS requirements and plans are generated by a technical analytic procedure called Logistics Support Analysis (LSA). LSA is scheduled to be combined with Manpower, Personnel and Training analysis and then be renamed Weapon System and Equipment Support Analysis. Specifications for these types of analyses are given in MIL-STD 1388. Neither the present version

nor the proposed revision[12] of this military standard mention technical assistance or the Logistics Assistance Program.

e. Advantages of putting LAP into ILS.

(1) Planning. Identifying a logistics assistance support plan as an early ILS requirement would encourage the MSCs and other interested parties to form a support plan for estimating requirements for a multiyear period. (At present most FMT requirements projections are simply a rewrite of the current year's requirements.) ILS responsibilities of the supporting command continue through the system's life cycle. In particular, the supporting command is to provide[9] "analyses and assessments of field data feedback related to materiel system and logistic support performance. The results of these analyses and assessments will be used to adjust support requirements and provide baseline data for similar system developmental programs." Such periodic analyses and support adjustments would be extremely useful for the Logistics Assistance Program. Thus, inclusion of LAP requirements within the Integrated Logistics Support concept should enable the MSCs to better plan and budget for their recruitment and training of FMTs.

(2) Credibility. Inclusion of LAP needs within ILS would result in FMT requirements being determined concurrently with other support requirements. The MACOM requests for validation of FMT requirements could then be satisfied via the ILS analytic techniques which generate and validate other system support components. This would increase the visibility and credibility of FMT requirements.

(3) Improve ILS. Consideration of LAP resources and requirements will make ILS more realistic. Involvement of LAP personnel will significantly increase the expertise available for ILS planning.

f. The US Air Force is already integrating consideration of detailed technical assistance needs with other logistics requirements of individual weapon systems. See Appendix I for more details about the US Air Force planning for technical assistance.

3. Centralized System Planning.

a. FMT requirements would be more credible if the methods used by the MSCs in calculating their requirements were more visible. One method of making this process more visible would start with each MSC preparing and distributing for each major system or function being supported a support formula indicating how many FMTs are needed to support a given or standard set of equipment. Then at each installation, relating its system density to the support formula would yield the basic FMT requirement. This quantity modified by the special needs or characteristics of the installation would yield the estimated FMT requirement. Finally if these parameters--support formula, installation equipment density, and installation special needs--could be recorded on the same form as the estimated FMT requirements, the basis for the requirements would be visible to all concerned parties.

b. The support formula should indicate the supporting MSC, the systems or functions being supported, the amount of equipment or level of force unit considered standard and the appropriate MACOM if any. The support formula would then indicate the level of support needed--i.e., how many FMTs should support the standard amount or set of equipment. Hypothetical examples of such support formulas could be:

MICOM - HAWK, battalion (USAREUR), 3 MMT

TACOM - M2/M3, installation, 2 FMTs

TSARCOM - Power generators, division, 1 FMT

CECOM - Surveillance radar, region, 1 FMT

ARRCOM - Armament, brigade, 1 FMT

CECOM - Avionics, ACR (OCONUS), .5 FMT

TSARCOM - Aviation, 70 helicopters, 1 FMT

c. It would be desirable to put the support formula into a support plan which contains related and supportive information. The support plan should, for example, also project the support level over a specified time period so that the installation FMT requirements could also be projected. Values of supporting type data such as Reliability, Availability, Maintainability-Durability (RAM-D) characteristics, mission, operation readiness (OR) ratings, and associated FMT skills and training times should be included. Besides tending to support the MSC's decision on what the support level should be, this data would also be used later to partially automate the computation of support levels.

d. Examples of sample forms that might be used to implement the support formula and system support plan are in Appendix J.

VI. Findings and Conclusions (references are to the Main Report and Appendices).

A. Findings.

1. There is no historic data base of FMT requirements, fills, and specialties (Paragraph VD1).

2. The Major Subordinate Commands have very different methods to determine FMT requirements (Paragraph VB2).

3. The present requirements determination system involves many groups, each estimating requirements and is thus very complicated and often confusing (Paragraph VB1c, VC1).

4. Recent projections have often been repetitions of current requirements. The special needs of many major systems scheduled for deployment have not been adequately addressed (Paragraph VC2, VC5, and Appendices B, C, D).

5. Specific Logistics Assistance Program assets and requirements are often omitted in the Integrated Logistics Support planning for major systems (Paragraph VD2).

6. Many FMT requirements, especially OCONUS, remain unfilled (Paragraph VC4).

7. A frequent complaint that FMTs spend too much time on supply matters appeared in interviews with users, FMTs and Logistics Assistance Office personnel, and in various previous studies of LAP (Paragraph VC3).

B. Conclusions.

1. Predictive and accurate regression models for FMT requirements cannot be produced because sufficient data is unavailable (Paragraph VD1).

2. MSCs need to use a more widely understood and centralized methodology to determine requirements (Paragraph VD3).

3. Present staffing patterns show that MSCs differ in degree of FMT specialization and in the basis for FMT man years--density equipment, complexity of equipment, or number of force units equipped (Paragraph VB3).

4. The present LAP policy of providing long term support to various major weapon/equipment systems is justified. Institution of a policy to terminate FMT requirements for systems deployed two years or longer is unrealistic (Paragraph VA3 and Appendix A).

VII. Recommendations (references are to the Main Report and Appendices).

A. For each supported system, the MSCs should prepare a Support Formula indicating how many FMTs are needed to support the system at particular types of installations or force units. The Support Formula could be in the form of a staffing guide. It would be preferable to have it embedded in a support plan which would include realistic projections of the Support Formula and information on the supported system and FMT skills and performances (Paragraph VD3, Appendix J).

B. Logistics Assistance Program requirements should be included in Integrated Logistics Support (ILS) plans. To accomplish this the following changes should be made (Paragraph VD2).

1. Include technical assistance as an element of ILS in AR 700-127.

2. Specify in MIL-STD 1388 that all weapon system and equipment support analysis to determine manpower, personnel, and training needs should consider the requirements and resources of LAP and other sources of technical assistance.

3. DARCOM Circular 700-9-4 should instruct that materiel fielding plans estimate specific quantities and types of technical assistance required to field a new system.

C. A priority system for filling FMT requirements should be formulated. Such a system could be user generated or be based on the operational readiness criteria or amount of equipment usage (Paragraph VC4, Appendix F).

D. The problem of possible excessive supply work for FMTs should be researched. It should be determined if the problem is real and whether it comes from unrealistic expectations of the users, inadequate supply training of the FMTs, inadequate attention from the Logistics Management Specialists in the LAOs, inadequate numbers of Field Supply Technicians from the MSCs, or still other causes (Paragraph VC3).

APPENDIX A

USER PERCEPTIONS ON LAP STAFFING

The Logistics Assistance Program (LAP has the mission of assisting Army operational and maintenance units. Personal interviews were conducted with LAP users at various levels--MACOM, installation, unit. These people were asked their perceptions about the quantity and quality of LAP support, whether they felt there were too many or too few FMTs, and finally they were asked for suggestions on what FMT staffing changes would improve LAP support.

Most of the users were quite complimentary about their LAP support. They said that the FMT would often identify a problem and even solve it before the problem was even known at command level. During one interview with a divisional maintenance officer, a general called about an aviation problem. The officer called the FMT's office and learned that the FMT was already on the scene working on the problem. This same officer told about another problem he had asked an FMT about. The FMT directed him to a memo he had already submitted to the officer's unit detailing the potential problem and its solution.

On the question of staffing levels, each installation and unit maintenance person interviewed felt that his organization could use more support and that the number of FMTs should be increased. One DIO commander was interviewed who has his own expert civilian work staff and so did not utilize LAP support. He said his staff would sometimes collaborate on joint projects or exchange technical information with FMTs. From his somewhat disinterested position, he felt LAP was providing good service but that in terms of staffing "we should just double the present number" of FMTs.

One FORSCOM administrator had a view vastly different from those expressed by installation and unit personnel. He felt there were in general too many FMTs

and that the over supply of FMT support acted as a crutch for the unit commander. He felt, for example, that LAP support should cease for equipment deployed more than about two years and that if LAP were curtailed, the commander would either ensure that people on his own TDA or MTOE could handle the resulting logistics problems or he would find the resources to contract out assistance services his own staff could not provide. He cited Fort Hood as a place where much of the training not available from unit personnel was being contracted out. He suggested that the installation maintenance officers be asked why they cannot take over many of the LAP activities.

Clearly, the reassignment of LAP duties to other Army organizations and the limitation of LAP equipment support to a two-year or similar period would result in a substantial decrease in LAP manpower requirements. Therefore, the issues raised at FORSCOM were discussed with user and LAP personnel during subsequent visits to Forts Bliss and Hood

Should LAP support cease after 2 years?

Both providers and users of LAP interviewed claimed that, conventional wisdom aside, the need for logistics assistance often remains constant or even rises after equipment has been deployed for about two years. One reason is that due to frequent Product Improvement Programs (PIPs) and other modifications, equipment often remains essentially new for many years. Another reason is that, due to the high turbulence within the military, personnel assigned to operate and maintain complex equipment often are not experienced with their equipment. Also, the need for assistance sometimes rises as the troops who received intensive training from New Equipment Training Teams (NETT) get replaced by personnel with only apprentice level training from TRADOC schools. The actual decrease in LAP support for equipment deployed two years or more depends on the above factors--degree of equipment modification, troop turbulence, and training--as well as the development of historical Reliability/Availability/

Maintainability (RAM) data for the particular system.

Should LAP activities be reassigned?

Users and providers of LAP were asked to comment on whether LAP should be reassigned to the units themselves, to the installations, or to contractors. The main obstacle to having LAP functions transferred directly to the supported units is the lack of qualified personnel. Besides contributing to a lower level of competence in the entry level troops, the high military turbulence has led to a drastic decrease in the number of experienced Non-commissioned and Warrant Officers. It is this very situation that has resulted in a greater need for LAP activities recently. Installation civilian maintenance work forces do have the expertise to provide logistics assistance. If this function were transferred to the installations, their work forces would of course have to be augmented. An important problem, however, is that locally based civilians are not likely to deploy with a military unit into a hostile area. Although FMTs presently are not legally obligated to so deploy, historically the majority has deployed when requested to do so. There are two other disadvantages in transferring LAP duties to unit or installation personnel. First, the MSC connection would be lost. This connection of the FMT back to his MSC employer is important in obtaining requisition assistance from the MSC staff and in transmitting logistics and product improvement information between the user and the MSC. Second, unit personnel often feel more open in expressing their needs to persons outside their command. Maintenance Assistance and Instruction Teams (MAIT) and other with-in command groups are often viewed as inspection and not assistance groups.

Is contractor support preferable?

A possible replacement for the present MSC supplied FMT assistance is the use of contractors. As the FORSCOM interview stated, there have been some

contractor instructional and assistance services at Fort Hood recently. These services have been of two types. First, various contracts have been let with the local junior college, Central Texas College, to provide remedial courses in reading, writing, and arithmetic skills. Clearly these services do not compete with LAP. Second, there was a $20,000 contract with Motorola for 4-6 weeks of electronics technical assistance with the Mohawk aircraft. Fort Hood CECOM and installation personnel said this contract was let because the CECOM requirements to support Mohawk systems were not recognized or filled. (See Appendix B for a discussion of Fort Hood requirements.)

Various people at Fort Hood expressed the view that for low level training needs contract support was adequate and efficient but that for advanced technical assistance LAP was much the preferred source. LAP was much more flexible--providing formal and informal training as well as diagnostic help and MSC liaison--whereas a contract usually specified beforehand exactly which type of services would be provided. LAP was available all year while often contract support was only for a specified time period. LAP support was usually much less expensive than contractor support. In fact, a recent study[13] on Technical Assistance by the Defense Audit Service recommended extreme caution in substituting contractors for DA civilians and emphasized that contractor support was often twice as expensive. Using local contractors would lead to some of the same problems as using installation personnel--namely, these people would lack the MSC connection and would be unlikely to deploy into hostile areas. The use of centrally supplied contractor services would be very expensive. If the contractor was also the equipment manufacturer, as has often been true, his enthusiasm for revealing and publicizing product deficiencies would be suspect.

Can FMTs be used more effectively?

Interviewees pointed out two situations which limit the effective use of FMT services. First, the lack of sufficiently many Field Supply Technicians

leads to a larger than desirable supply assistance role for FMTs, especially at Fort Hood. Second, the question of adequate supervision of FMTs was often raised.

In theory each MSC supplies two types of technical assistance personnel--Field Maintenance Technicians (FMTs) whose primary mission is assistance with maintenance and operations and Field Supply Technicians (FSTs) whose primary mission is assistance with specific equipment or system supply problems. (DARCOM hires Logistics Management Specialists (LMSs) who help with logistics problems that are not specific to one type of system or equipment.) In practice there are very few FSTs and the almost universal complaint from LAP and installation personnel was that there were many unfilled, and often officially unrecognized, requirements for FSTs. One Logistics Assistance Coordinator estimated that 60% of his FMT manpower was used to provide supply assistance. At a 13th SUPCOM briefing at Fort Hood, attended by the study author, the subject covered was equipment long out of operation and in many cases the problem was attributed to a lack of repair or replacement parts and the supporting FMT was requested to assist in promptly securing such needed parts. Many interviewees felt that if more FSTs were assigned to the LAOs, then the FMTs could concentrate on their primary mission of maintenance support.

Many interviewees felt there was inadequate supervision of FMTs. Although each LAO chief can task and coordinate FMT activities, the immediate supervisor of the FMT is an MSC individual, often a Senior Staff Technical Representative (SSTR), who may be located a thousand miles or more from the FMT. Personal visits and observations of the FMT by his supervisor are infrequent, sometimes even less than twice a year. Besides being spontaneously mentioned by various people interviewed for this study, the adequacy of supervision problem was surfaced at recent workshop meetings of the LAP managers from DARCOM and the MSCs.

Possible solutions mentioned have been the upgrading of the local Logistics Assistance Coordinators to the status of SSTR, the assigning of more supervisors or the transferring of supervisory and rating functions from the MSCs to the local Logistics Assistance Offices (LAO). Occasional problems attributed to inadequate FMT supervision included inappropriate division of time on FMT tasks, inadequate attention given to some tasks, general lowering of FMT morale and motivation and confusion of responsibility between LAO tasking and MSC supervision of the FMT.

These two problems of lack of FSTs and inadequate supervision were raised by many interviewees. To the extent that each problem decreases FMT effectiveness, it thereby impinges on FMT requirements. These problems also have surfaced in previous studies, e.g., pages 131, 151 of the Bryant and Miletich Study[4] of 1975.

Summary.

Most of the users interviewed said they were receiving good support from the Logistics Assistance Program. They felt an increase in FMT staffing would be beneficial. None of them agreed with the view of the individual from FORSCOM who advocated a curtailment of LAP services. In general, they felt that providing logistics assistance from a source other than the MSCs would result in lower quality or more expensive services and would not increase the commanders internal ability to solve his logistics problem. Moreover, such a change would likely decrease the probability of logistics support following a deploying unit into a hostile zone. Two LAP problems pointed out were a lack of Field Supply Technicians and inadequate supervision of FMTs.

APPENDIX B

FMT REQUIREMENTS FOR FORSCOM/WESTCOM

In this section the FMT requirements at FORSCOM installations are examined. The WESTCOM requirements are fairly small and are mostly for support of the 25th Infantry Division and the National Guard and Reserve Forces in Hawaii. The situation in Hawaii, of an Army force consisting mainly of one division stationed at a home American post, is similar to that of a FORSCOM installation. Thus, the WESTCOM requirements will be studied together with the FORSCOM requirements.

Table B-1 summarizes the FORSCOM recognized requirements for FY 81 and the projected requirements for FY 82 through FY 84. Also included are the FY 81 fill and the ratio of fill to requirements in FY 81. Table B-2 contains the same type of data for WESTCOM requirements. The data for both tables come from the DARCOM Manyear Requirement forms for 1981.

Notice that CSLA has no filled requirements, CECOM has about 81% fill and the other MSCs have approximately 90% fills in their FORSCOM requirements. Only CECOM shows a substantial change in requirements from FY 81 to FY 84. This increase is due mainly to support new TACFIRE and FIREFIGHTER system deployments and to projected signal and electronic warfare communications support at Forts Hood and Lewis. (Although it does not yet appear in the DARCOM forms, other FORSCOM installations may also soon have a SIG/INT/EW requirement.) Notice finally from Table B-2 that almost all the requirements at Hawaii are being filled.

Table B-3 indicates the 1982 requirements at FORSCOM and WESTCOM installations. The data for Fort Hood comes from interviews there with the Logistics Assistance Coordinators for the MSCs. Some of these requirements, especially for CECOM, were substantially higher than the MSC and MACOM projected requirements. The

TABLE B-1

FORSCOM FMT REQUIREMENTS

	FY 81 REQ	FY 81 FILL	FY 82*	FY 83*	FY 84*	FY 81 FILL/REQ
ARRCOM	27	25	27/29	27/29	27/29	.93
TACOM	23	21	22/23	22/23	22/23	.91
CSLA	3	0	3	3	3	0.00
TSARCOM	63	56	63/67	63/67	63/67	.89
AVIATION	43	38	43/45	43/45	43/45	.88
GROUND	20	18	20/22	20/22	20/22	.90
MICOM	30.5	28	28/30	28/30	27.5/29	.92
CECOM	47	38	53/55	57/59	59	.81
AVIONICS	15	12	15	15	15	.80
RADARS	11	7	12	12	12	.64
ADP/TF	4	2	6/7	10/9	12/10	.50
COMMO	17	17	18	18	18/19	1.00
SIG/EW	0	0	2/3	2/3	2/3	-

* n/m indicates the MSC projects n and the MACOM projects m as the requirement.

TABLE B-2

WESTCOM FMT REQUIREMENTS

	FY 81 REQ	FY 81 FILL	FY 82*	FY 83	FY 84	FY 81 FILL/REQ
ARRCOM	2	2	2	2	2	1.00
TACOM	4	4	4	4	4	1.00
CSLA	0	0	0	0	0	-
TSARCOM	5	4	5	5	5	.80
AVIATION	3	3	3	3	3	1.00
GROUND	2	1	2	2	2	.50
MICOM	2.5	2.5	3	3	3	1.00
CECOM	5	5	5/6	6	6	1.00
AVIONICS	1	1	1	1	1	1.00
RADARS	1	1	1	1	1	1.00
ADP	1	1	1	1	1	1.00
COMMO	1	1	1	1	1	1.00
SIG/EW	1	1	1/2	2	2	1.00

* n/m indicates the MSC projects n and the MACOM projects m as the requirement.

TABLE B-3

1982 FORSCOM INSTALLATIONS REQUIREMENTS

INSTALLATION	UNIT	ARRCOM	TACOM	CSLA	TSARCOM		CECOM					MICOM				
					AVTN	GRND	COMMO	RADAR	AVIONC	SIG/EW	ADP/TF	CFR	LTD	TC	HAWK	TSQ73
BRAGG	XVIII ABN CORPS 82D ABN DIV	2	2	1	6	2	3	2	1	0	1	1	1	1	1	1
CAMPBELL	101ST ABN DIV	3	2	0	7	2	1	1	1	0	1	1	1	1	0	0
CARSON	4TH INF DIV (M)	3	3	0	4	1	1	1	1	1*	1	1	1	1	0	0
HOOD	III CORPS (+OTHER)	1.0	0	1	1.2	1	1	0	6	6	1	0	0	0	0	0
	1ST CAV DIV	2.8	4	0	2.2	1	1	1	1	1	2	1	1	0	0	0
	2D ARM DIV	2.7	4	0	1.3	1	1	1	1	1	1	1	1	.3	0	0
	6TH ACC BDE	0.5	0	0	3.3	1	1	0	1	0	0	0	0	.7	0	0
IRWIN	NAT TRN CTR	2	1	0	0	1	1	0	0	0	0	0	0	0	0	0
LEWIS	9TH INF DIV NBC BN	3	2	0	5	2	1	1	1	1	1	1	1	1	1	0
ORD	7TH INF DIV	2	2	0	3	1	1	1	1	0	0	1	1	1	0	0
PANAMA	193D INF BDE	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
POLK	5TH INF DIV (M)	2	2	0	1	1	1	1	1	0	0	0	1	1	0	0
RICHARDSON	172TH INF BDE	1	1	0	3	1	1	0	1	0	0	0	0	0	0	0
RILEY	1ST INF DIV (M)	2	3	0	2	2	1	1	1	1*	1	0	1	1	1	1
STEWART	24TH INF DIV	3	3	0	6	1	1	1	2	0	0	1	1	1	0	0
MCPHERSON	HQ FORSCOM	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0
HAWAII**	25TH INF DIV	2	4	0	3	2	2	1	1	1	1	1	1	1	0	0

* These requirements were identified by the regional CECOM supervisor but do not appear on the DARCOM Manyear Requirements sheets.

** Hawaii is part of WESTCOM. It is included with FORSCOM for analysis purposes.

requirements at the other installations were obtained from the Manyear Requirement forms filled out by the MSCs, MACOM, and installations and then sent to DARCOM.

The ARRCOM and TACOM requirements are approximately one per brigade. We also compiled the average ARRCOM and TACOM support for different types of divisions. For this computation we consider airborne, air mobile, and infantry divisions as "light." The Second Armored Division at Fort Hood is treated as a mechanized division since it has one brigade deployed forward in Europe. Also, the 25th Infantry Division in Hawaii is treated as "armored" since the requirements for it also include substantial National Guard and Reserve Forces requirements. The average support is summarized in Table B-4. The ARRCOM averages are surprising since one expects that a more heavily armored division would have a greater ARRCOM requirement. The TACOM averages are as expected. Note that, of the three non-divisional brigades in Table B-3, the one in Alaska had a TACOM requirement and the ones in Panama and Fort Hood did not.

The TSARCOM aviation requirements seem very variable; however, they are closely related to the density of helicopters at each installation. Their distribution is well described by the Ratio Sum Model explained in Appendix E. An adequate approximation of their distribution is also obtainable by considering that approximately 55 helicopters should be supported by one FMT manyear. The TSARCOM ground support FMT requirements are also fairly variable. There appears to be basically two FMTs per airborne division and one FMT per other division or non-divisional brigade.

The CECOM requirements are of two types. For each division there is a standard requirement of one FMT each in Communications, STANO (radars, etc.) and Avionics. As the divisions acquire more electronic data processing equipment,

TABLE B-4

AVERAGE FMT SUPPORT PER FORSCOM UNIT

	ARRCOM	TACOM
CORPS	0.43	0.00
ARMORED DIV	2.40	4.00
MECH DIV	2.54	3.00
LIGHT DIV	2.14	2.00
BRIGADE	0.50	0.33

signal and electronic warfare equipment and TACFIRE and FIREFINDER systems, they are requiring one FMT each in the SIG/INT/EW, ADP/TACFIRE and FIREFINDER specialties. Each non-divisional combat brigade has a requirement for one Communications FMT and those with substantial quantity of aircraft also require an Avionics FMT. Signal brigades and military intelligence groups generate large Avionics and Signal/Intelligence/Electronic Warfare requirements.

The SIG/INT/EW requirements of CECOM are the most controversial. Of the 11 FORSCOM requirements for 1982 identified by CECOM personnel, only two are recognized by FORSCOM and DARCOM.

The MICOM requirements are basically one specialist each in the CHAPPARAL/FARR/REDEYE, LCSS/TOW-DRAGON and the TOW-COBRA systems for each division. Also each HAWK ADA Battalion needs one FMT with an additional FMT if it has the TSQ-73 system deployed.

The Communications Security Logistics Agency (CSLA) requirements are at the CORPS and MACOM headquarters.

The foregoing analysis explains almost all of the FORSCOM/WESTCOM requirements. Table B-5 shows the "unexplained" requirements. Forts Irwin and McPherson appear in this table because our analysis only covers installations housing major permanent FORSCOM/WESTCOM units. The large negative differences at Forts Bragg and Campbell reflect the fact that the aircraft support ratios are very high for the two CONUS Airborne divisions. For purposes of computing the differences in Table B-5, the ARRCOM support averages from Table B-4 were rounded off to .5, 2.5, 2.5, 2, .5 manyears for each corps, armored division, mechanized division, light division and brigade respectively. Part of the "unexplained" ARRCOM effort is in support of a chemical company at Fort Lewis.

TABLE B-5

UNEXPLAINED FORSCOM/WESTCOM REQUIREMENTS

	ARRCOM	TACOM	TSARCOM		CECOM					MICOM	
			AVN	GRD	COMMO	RADAR	AVNC	SIG/EW	ADP/TF	CFR	TC
BRAGG	-.5		-1.2		1	1		-1			
CAMPBELL	1.0		-4.4	1				-1			
CARSON	.5		1.5								
HOOD	1.0	.5	0.1				6	6			-2
IRWIN	2.0	1		1	1						
LEWIS	.5		0.4	1							
ORD			-.7					-1			
PANAMA	-.5	-.5									
POLK	-.5	-1						-1		-1	
ALASKA	.5	.5	0.7								
RILEY	-.5		0.5	1						-1	
STEWART	.5		3.4		1		1	-1			
McPHERSON					1		1				
HAWAII	-.5		0.2	1							

APPENDIX C

FMT REQUIREMENTS FOR USAREUR

Table C-1 summarizes the recognized USAREUR requirements for FY 81 and the projected requirements for FY 82 to FY 84. Also included is the FY 81 fill and the FY 81 fill to requirements ratio.

A rather surprising feature of the USAREUR set of requirements is that all the requirements except for those from MICOM seem to be static. For each of the fiscal years 1982, 1983, 1984 the requirements determined by the MSC, by the MACOM, and by the installations are essentially the same. (The only non-MICOM difference between USAREUR and MSC is the requirement for one chemical specialist from ARRCOM at Zweibruecken.) Also the projections for FY 1982 through FY 1984 are all essentially the same as the recognized requirement of FY 1981. (Except for MICOM, the only changes are two new requirements for CECOM and two additions and one deletion in the ARRCOM requirements.)

The apparent uniform agreement between USAREUR and the MSCs is mostly due to the manner in which the USAREUR requirements were generated. These requirements were determined at a conference attended by representatives of USAREUR, the LAOs, and the MSCs. Thus, the USAREUR requirements document shows only the coordinated requirements (again except for MICOM). The requirements for the other MACOMs were determined according to DARCOM Regulation 700-100; i.e., they started at an MSC headquarters, regional or local office, then went to the MACOM LAO, then to the installation LAO and HQ, then back to the MACOM LAO and HQ and finally back to the MSC. Thus, in the non-USAREUR cases the requirements sheets indicate a number of disagreements among the MSC, MACOM, and installation levels. (Most of these conflicts were eventually settled by agreeing to the MACOM determined requirements.)

TABLE C-1

USAREUR FMT REQUIREMENTS

	FY 81		FY 82*	FY 83*	FY 84*	FILL/REQ
	REQ	FILL				
TACOM	45	35	45	45	45	.78
ARRCOM	32	33	32/33	32/33	32/33	1.03
CSLA	18	6	18	18	18	.33
MICOM	72	71	66/76	72/82	81/91	.99
PERSHING	8	7	8	11	11	.88
LANCE	3	3	3	3	3	1.00
MLRS	0	0	0	1	2	-
LCSS	3	3	3	3	3	1.00
TOW DRAGON-SHILL	7	7	6/8	4.5/6.5	4.3/6.3	1.00
TOW COBRA	5	5	5	2.5	1.7	1.00
HELLFIRE	0	0	0	2	3	-
HAWK	25	25	19/25	19/25	19/25	1.00
HERCULES	5	5	4/5	4/5	4/5	1.00
CHAP/FARR/REDEYE/ STINGER	4.7	4.7	8	8	8	1.00
TSQ-73	11	11	10/11	10/11	10/11	1.00
PATRIOT	0	0	0	4	11	-
CECOM	96	47	98	98	98	.49
RADARS	13	7	13	13	13	.54
COMM	49	26	50	50	50	.53
ADP	5	3	5	5	5	.60
AVIONICS	15	9	15	15	15	.60
FIREFINDER/TACFIRE	7	0	8	8	8	0.00
SIG INT/EW	2	0	2	2	2	0.00
OTHER	5	2	5	5	5	.40
TSARCOM	52	31	53	53	53	.60
GROUND	26	11	27	27	27	.42
AVIATION	26	20	26	26	26	.77

* n/m indicates the MSC projects n and the MACOM projects m as the requirement.

The fact that, except for MICOM, USAREUR requirements seem not to change from FY 81 to FY 84 is more difficult to explain. Deployment of the Abrams Tank, the Bradley Infantry and Cavalry Fighting Vehicles, the Black Hawk Helicopter, and new English Bridging equipment seems to have generated no new requirements.

MICOM is the only exception to the static requirements situation discussed above. There is substantial difference (10 positions) in the MICOM and USAREUR initially determined requirements. The total MICOM determined requirements--72, 66, 72, 81 respectively for FY 81, 82, 83, 84--were certainly non-constant Actually the variability is even more pronounced when one considers that of the missile specialties there were increases in 5, decreases in 3, and no change in only 4 of them. Requirement increases seem to be based on upgrading of the Pershing, the introduction of new systems such as the Patriot and Multiple Launch Rocket System (MLRS), and new deployments of STINGER.

The percentage of FY 1981 requirements filled varies from 103% to 33%. MICOM and ARRCOM essentially have all requirements filled. TACOM and the ground support TSARCOM requirements have 77-78% fills. CECOM, CSLA, and the ground support requirements of TSARCOM are all less than 50% filled. Note also that two of CECOM's new systems, FIREFINDER and TACFIRE, together have seven requirements identified for FY 1981, none of which were filled. This situation leads to a credibility problem.

TABLE C-2

USAREUR FMTS BY FORCE UNIT

	MICOM											CECOM					TACOM	ARRCOM	TSARCOM	
	PERSH	LANCE	MLRS	LCSS	TOW D	TOW C	HELLF	HAWK	HERC	CFRS	TSQ 73	STANO (B)	COMMO	SIGEW	ADP (C)	AVNC			GEN	AVT
ARTY/ORD BN(A)	D	.5		1	2.5			2.5	1	.7	.7									
DIV					1							1	2.5		.1	1	3	3	1	
CORPS (G)			E									1	3	1	2		4	3		
ACR						1	H						1			.5	1	2	.5	2
ACC BDE						F	H													2
ADA BDE/GRP								1				2	2						1	
CBT BDE												.5	1				1	1	1	
ENG BDE																	1		1	
SIG BDE/BN													1							
MN BN												.5	1						1	
AV/TRANS CO																1				2.5

NOTES

A - LANCE SUPPORT FOR LANCE BN, etc.
B - FIREFINDER, RADAR, NIGHT VISION DEVICES, ETC.
C - INCLUDES TACFIRE
D - TRANSITIONING FROM 2 PERSHING I FMTS TO 3 PERSHING II FMTS
E - TRANSITIONING FROM 0 TO 2 FMTS PER CORPS
F - TRANSITIONING FROM 1 FMT TO 1/3 FMT
G - INCLUDES CORPS SUPCOM
H - TRANSITIONING FROM 0 TO .5 FMTS

Table C-2 indicates the distribution of FMTs in USAREUR by specialty and force unit. The 0.7 FMTs support for CHAPARAL-FARR-REDEYE-STINGER and for the TSQ-73 reflect the fact that each FMT supports either one or two battalions. Support for PATRIOT is being planned on the basis of initially providing 2 or 3 FMTs per PATRIOT battalion. Much of CECOM's communication and avionics support goes to assorted ordnance brigades and battalions, military intelligence units, etc., and is not reflected in Table C-2. TSARCOM Aviation FMT support is not as closely related to aircraft density by location as in CONUS. Presumably this situation is due to the separation of organizational and intermediate aviation maintenance in Europe.

APPENDIX D

FMT REQUIREMENTS FOR TRADOC

The total requirements for TRADOC show similarity with the requirements for USAREUR in that only MICOM requirements show variability over time. Some of the requirements by installation are amenable to regression analysis. Using this analysis and other observations, most of the FMT requirements at TRADOC installations can be quite well accounted for. The major exception is the TRADOC requirements used for support to National Guard/Reserve Component units.

The total TRADOC requirements and fill for FY 1981 and the projected requirements for FY 1982-1984 are summarized in Table D-1. Note that the FY 1981 recognized requirements were completely filled by MICOM and TACOM, completely unfilled by CSLA and 74% - 80% filled by the other MSCs. The seeming decrease in TSARCOM requirements is due to an erroneous omission of three positions for National Guard Support. Except for MICOM, the projected MSC requirements are constant for the period FY 1982-1984. ARRCOM and CECOM show a moderate decrease from FY 1981 to FY 1982. For the period FY 1981 to FY 1984, MICOM shows a 28% increase in requirements--mainly due to scheduled deployments of the PATRIOT and MLRS missile systems.

Many of the FMTs located at TRADOC installations actually support major FORSCOM units stationed at those installations or National Guard or other reserve forces in the area. Starting in FY 1982, the requirements needed primarily to support National Guard/Reserve Forces will be indicated separately from the requirements in support of Active Army units.

Table D-2 shows the FY 1982 requirements for TRADOC installations. The Fort Bliss requirements are further divided into requirements for the 3d ACR, the 11th ADA Brigade, and the remainder of Fort Bliss. These Fort Bliss requirements come from interviews with the Logistics Assistance Coordinators--the team leaders

TABLE D-1

REQUIREMENTS AT TRADOC (INCLUDING NATIONAL GUARD)

	FY 81 REQ	FY 81 FILL	FY 82*	FY 83*	FY 84*	FY 81 FILL/REQ
ARRCOM	15	12	14/15	14/15	14/15	80%
TACOM	22	22	22	22	22	100%
CSLA	1	0	1	1	1	0
MICOM	21.75	21.75	25.25/25.75	27.25/28.25	27.25/27.75	100%
Air Def	14	14	19	20	19	100%
Land Combat	7.75	7.75	6.25/6.75	7.25/8.25	8.25/8.75	100%
TSARCOM	23.2	17.25	20/24.25	20/24.25	20/24.25	74%
Aviation	16.2	12.25	12/15.25	12/15.25	12/15.25	76%
Ground	7	5	8/9	8/9	8/9	71%
CECOM	19	15	16	16	16	79%
Comm	12.5	10	10.5	10.5	10.5	80%
Avionics	2	1.5	2	2	2	75%
Radar	3	3	2	2	2	100%
Tacfire/ Firefinder	1.5	0.5	1.5	1.5	1.5	33%

* n/m indicates that the MSC projects n and the MACOM projects m as the requirement

TABLE D-2

PROJECTED 1982 TRADOC REQUIREMENTS

LOCATION	UNIT	ARRCOM	TACOM	TSARCOM		CECOM			MICOM	
				GND	AVN	COMM	AVNC	OTHER	LCSS TOW/ DRAGON	OTHER
Belvoir	Engr Ctr	0	1	1	0					
Benning	197 Inf Bde,Inf Ctr	1	2	0	2	1	0	0	.5	
Bliss	3d ACR	1	2	.5	1	.5	.5	0	.5	.5
	11th ADA Bde	.5	1	1	0	1.5	.25	0	.5	7.0
	Air Def Ctr,etc.	1.5	2	1.5	1	1	.25	0	0	7.5
Dix	Tng Ctr, NG	1	1	1	1	1	0	0		
Devens	National Guard	1	1	0	1	1	0	0	1	
Eustis	Trans Sch	0	1	3	1	.5	.5	0		
Gordon	Signal Sch	0	1	0	0	2	0	0		
Jackson	Tng Ctr	1	1							
Knox	194 Arm Bde, Arm Ctr	3	4	1	1	1	0	0	.5	
L. Wood	Tng Ctr	1	2							
Rucker	Avn Ctr, NG	1	1	0	1	.5	.5	0	0	.5
Sill	III Corps Arty, Arty Ctr	2	2	1	2	.5	0	1.5	0	4

of FMTs from the various MSCs. The other requirements were obtained from the Manpower Requirement sheets sent to DARCOM by the MSCs in 1981.

Certain categories of FMT support to TRADOC installations seem amenable to regression analysis. These categories (and the abbreviations used) are:

ARRCOM - ARRCOM support

TACOM - TACOM support

GND - Ground forces support from TSARCOM

AVN - Aviation support from TSARCOM

COMM - General communications support from CECOM

AVNC - Avionics support from CECOM

Primarily regression is used to see if:

X - the number of major TRADOC centers or schools

Y - the number of major FORSCOM units

can predict

Z - the FMT man-year requirement

Our statistics notation and definitions are explained in Appendix H.

The first question to study is whether a constant term is appropriate, i.e., is the model

(1) $$Z = \alpha X + \beta Y + \text{error}$$

preferable to the model

(2) $$Z = \gamma + \alpha X + \beta Y + \text{error}.$$

Note there are major difficulties in applying model (2) to the data. If model (2) is used, then the separate requirements from Fort Bliss must be combined into one set of requirements. This in turn leads to two problems. First, combining the Fort Bliss data leaves us with less detail; we are throwing away part of our knowledge of the situation. (Technically, the combined data has only 8 degrees of freedom, the separated data has 10 degrees of freedom.). A

more important problem is that in the combined data each observation has a value of 1 for X. Thus, with the combined data, model (2) is equivalent to model

$$Z = \gamma + \alpha.1 + \beta Y + \text{error}$$

Thus, there is no way of estimating separately the values of γ and α. (If one blindly tries to use this model with a computer statistics package, one gets a singular, non-invertible set of normal equations.)

Therefore, from practical and technical considerations, model (1) should be used in place of model (2). In an effort to see if model (2) even makes sense, it was applied to the non-combined data. In each of the six cases, either the estimate for γ was very close to zero (there was less than 20% confidence for the assumption that γ was non-zero) or one or both of the estimates for α and β were negative. Clearly as the number of TRADOC and FORSCOM units to be supported increases, the amount of FMT support must increase. Thus, a negative value for α or β is meaningless. Therefore, model (2), besides being impossible to apply, probably cannot provide any useful information at any rate. To test the consistency of model (1), it was applied to the data. In each case the estimated values for α and β were positive.

Next we examine the possibility that supporting two or more units would lead to greater efficiency since some of the slack time in supporting one unit could be used to support ancther unit. Thus, the model

$$Z = \alpha X + \beta Y - \gamma XY + \text{error} \tag{3}$$

was tested where

$$XY = 1 \text{ if } X + Y > 1$$
$$= 0 \text{ otherwise}$$

In the first four cases, the estimate for γ was either very close to zero or actually negative. In the two CECOM categories, however, the estimates for all the parameters were substantially positive and moreover the value for R^2 (i.e., the amount of square error accounted for by the regression equation) improved considerably over that for model (1).

Certain fairly large residuals arising from applying models (1) and (3) lead to the question of whether there is still another factor at work, namely, the requirement to fill certain special needs. For example, it seems reasonable that the Signal School at Fort Gordon may have special communications FMT needs, the Armor School may have special ARRCOM and TACOM needs, etc. Thus, we check the models

(4) $$Z = \alpha X + \beta Y + \delta W + \text{error}$$

and

(5) $$Z = \alpha X + \beta Y - \gamma XY + \delta W + \text{error}$$

with α, β, γ, δ non-negative

and $W = 0$ except $W = 1$ when

Z is	at installation
ARRCOM	Knox (Armor Center) and Sill (Artillery Center)
TACOM	Knox (Armor Center)
GND	Eustis (Transportation School)
COMM	Gordon (Signal School)

Table D-3 indicates the compiled estimated parameter values and the "goodness of fit" values R^2 and R_S^2 for the various models. As discussed above, some of the models do not include the parameters γ and δ. Table D-4 contains the residuals between the recognized requirements and those predicted by the models.

TABLE D-3

TRADOC REGRESSION RESULTS

Specialty	Estimates * for					
	α	β	γ	δ	R^2	R_s^2
ARRCOM	.47	.68	-	1.35	.86	.79
TACOM	1.08	1.20	-	1.71	.95	.93
GND	.62	.73	-	2.38	.87	.82
AVN	.58	.45	-	-	.59	.48
COMM	.50	1.00	.67	1.50	.89	.81
AVNC	.25	.375	.46	-	.60	.43

* Each model is $Z = \alpha X + \beta Y - \gamma XY + \delta W$ + error
Missing estimates correspond to missing terms in the model.

TABLE D-4

TRADOC MODELS RESIDUALS

	AR	TA	GND	AVN	COMM	AVNC
Belvoir	-.47	-.08	.38	-.58	-.50	-.25
Benning	-.15	-.29	.65	-1.03	.17	.33
3d ACR	.32	.79	-.23	.55	-.50	.125
11th ADA	-.18	-.21	.27	-.45	.50	-.125
Other Bliss	1.03	.92	.88	.42	.50	0
Eustis	-.47	-.08	0	.42	0	.25
Gordon	-.47	-.08	-.62	-.58	0	-.25
Knox	.50	0	-.35	-.03	.17	-.17
Rucker	.53	-.08	-.61	.42	0	.25
Sill	-.50	-.29	-.35	.97	-.33	-.17
df *	7	7	7	8	6	7
RMSE	.617	.494	.595	.681	.441	.253

*df is the residual degrees of freedom. RMSE is the Root Mean Square Error (See Appendix H).

Note that the residual degrees of freedom is 10 minus the number of parameters to be estimated. The root mean square error is a dispersion measure equivalent to the standard deviation.

Recall that R^2 and its normalized version R_S^2 are supposed to indicate how well the model fits the data. Considering the low values of these measures, we conclude that the aviation and avionics models do not adequately fit the data. We do, however, conclude that the model

$$Z = \alpha X + \beta Y + \delta W + \text{error}$$

fits the data for ARRCOM, TACOM, and TSARCOM ground support requirements and

$$Z = \alpha X + \beta Y - \gamma XY + \delta W + \text{error}$$

fits the data for CECOM communications FMT support.

APPENDIX E

AVIATION FMT REQUIREMENTS

The 1978 Byrne-Gray Study, Field Maintenance Technician Staffing Formulas, claimed a good linear regression fit between FMT requirements and the number of aircraft being supported. In this section we examine their analysis and try to extend the linear regression approach to explain much of the present FMT requirements.

On page 11 of their report, Byrne and Gray claim the correlation between FMT support and number of aircraft is low when all the aircraft assigned to an installation are counted and the correlation is high when only "active Army aircraft" are counted where the latter term refers to aircraft assigned to combat or medical units as opposed to a DIO or other post or logistics organizations. Their actual analysis appears in their Tab A. The model they examine is:

$$Y = \alpha + \beta X + \text{error}$$

where:

Y is the aviation FMT requirement

X is the number of active Army aircraft

The data they use is from the major FORSCOM posts. Using their data, one obtains the estimates

$a = 1.356$

$b = .00832$

with $R^2 = .796$ (See Appendix H for the definitions of a, b, and R^2.)

They claim that using regression analysis to relate FMT requirements to total number of aircraft at an installation results in a value $R^2 = .25$. However, they do not show their analytic work and do not state what data they used in that regression. Thus, the accuracy of $R^2 = .25$ could not be verified.

There are some problems with the manner in which they treat the Fort Hood data. Since Fort Hood supports two divisions, they used two Fort Hood entries, each listing half the aircraft and half the FMT aviation support. There are two problems with doing this. First, a regression model with a constant term ($\alpha \neq 0$) does not allow for arbitrarily dividing data at a given location. (Presumably each data set represents a location, not a division, since some of the data represents installations with FORSCOM battalions and not divisions.) Second, the aircraft and FMTs at Fort Hood are not actually equally divided between two major units. During the study author's visit to Fort Hood the TSARCOM Logistics Assistance Coordinator estimated the following distribution of FMT man-years at Fort Hood:

1st Cavalry Div	-	2.3
2d Armored Div	-	1.3
6th Air Combat Cav Bde	-	3.4
504th Military Intelligence Gp		1.0

Modifying Byrne and Gray's data by using these estimates and a more accurate accounting of aircraft by major unit at Fort Hood yields new values:

$a = 1.190$

$b = .00846$

$R^2 = .826$

Mainly due to the influence of α in the model, the equation fitted to the revised data computes a total requirement of 7.57 aviation FMTs at Fort Hood based on a total of 380 aircraft, while the originally fitted equation computes a requirement of 6.44 FMTs based on a total of 448 aircraft.

A more important problem with the Byrne-Gray approach is the inclusion of α in the model. The example above shows how sensitive this model is to

subdividing the data. Also there is the question of how to interpret α. The model fitted to the original data indicates that each installation needs 1.356 FMTs plus one FMT for each 120 aircraft. Does an installation with no aircraft need 1.356 FMTs? Does an installation with 80 aircraft need 2 FMTs?

Another difficulty with the Byrne-Gray method is that no distinction is made as to type of aircraft. Aviation FMTs mostly specialize in supporting one type of aircraft and each FMT requirement specifies what type of aircraft is to be supported. The variability in the number of aircraft supported per FMT is shown in Table E-1.

TABLE E-1

AIRCRAFT SUPPORT PER FMT

Area	Type Aircraft						
	All	OH-58	UH-1	AH-1	CH-47	UH-60	OV-1
USAREUR	47.8	50.1	82.4	38	15	-	28
FORSCOM * at Major Posts	54.8	69.2	82.4	45.7	22.5	26.5	11.3
Above without Bragg/Campbell	49.2	60.8	72.6	36.9	19.3	6.0	-
Bragg/Campbell	76.6	109	144	98.7	32	40	11.3

*Includes FORSCOM units stationed at TRADOC posts and in Hawaii.

The remainder of this appendix will describe our analysis of the present relation between FMT requirements and aircraft densities. For data the post or area requirements and aircraft densities for FORSCOM units at CONUS posts and in Alaska and Hawaii are used.

Fitting the Byrne-Gray model to the present data (with Fort Hood contributing only one entry), one obtains values:

$a = .850$

$b = .0131$

$R^2 = .802$

Because of the various problems coming from the presence of the intercept α in Byrne and Gray's model, we limit our own models to those with no intercepts, i.e., no α.

Various regression models were fitted to the data from the 15 American posts and areas. First the helicopters were separated out from the fixed-wing aircraft. The only fixed-wing FMT specialists were those assigned to support squadrons of OV-1 surveillance aircraft. There were only two such FORSCOM squadrons. The effect of the non-OV-1 fixed-wing aircraft on both the total number of aircraft and the FMT requirement at each post or area was also insignificant. Therefore, the fixed-wing aircraft were eliminated (including the OV-1) from our data base.

Next the helicopters and FMT requirements were classified by aircraft type - OH-58, UH-1, AH-1, CH-47, UH-60. The following models were fitted to the data:

$Y = \beta X + \text{error}$	with	X = total helicopters Y = FMT requirements
$Y = \beta X + \text{error}$		X = active Army helicopters Y = FMT requirements
$Y = \beta(\Sigma X_i/A_i) + \text{error}$		X_i = helicopters of type i A_i = aircraft per FMT of type i Y = FMT requirements
$Y = \Sigma\beta_i X_i + \text{error}$		X_i, Y as above
$Y_i = \beta X_i + \text{error}$		X_i = helicopters of type i Y_i = FMT requirements for type i

Since the support ratios as shown in Table E-1 are so different at Forts Bragg and Campbell, we then redid all the above regression analyses with Forts Bragg and Campbell data omitted. A summary of all these regression analyses is shown in Table E-2. (Recall that the definitions of b, R^2, and R_S^2 are in Appendix H.)

We draw the following conclusions from the values in Table E-2. First the relatively high values for R^2 and R_S^2 show that the aviation FMT requirements do in general relate closely to the density of aircraft--or at least of helicopters. Second, the distinction between total helicopters and active Army helicopters seems not to be very important. (About 10% of the aircraft are not "active.") The higher R^2 and R_S^2 values for the data without Forts Bragg and Campbell are expected since the support ratios, as shown in Table E-1, are so different. Of the four models describing the total FMT requirements, only the Ratio Sum seems sensitive to omitting the airborne divisions data. The models describing the specialized FMT requirements are more sensitive to the omission of airborne data. (The UH-60 model fits the non-airborne data exactly--$R^2 = 1$--since only one post has any UH-60 requirement.)

Note the inverse of the estimate b is a type of weighted average number of aircraft supported by one FMT. Except for the AH-1 these weighted averages are close to the averages in Table E-1. The Ratio Sum inverse b shows that the "best" Ratio Sum fit to all the data inflates the individual averages 21% and the "best" fit to the restricted data only inflates the individual averages by 8%.

The question now arises as to whether we can use these analyses outside of FORSCOM, in particular in USAREUR. Applying any of the models directly to the USAREUR aviation FMT requirements is difficult because unlike the FORSCOM

TABLE E-2

FORSCOM AVIATION FMTs REGRESSIONS

Model	Bragg Campbell	b	R^2	R_S^2	b^{-1}
Total	Yes	.01639	.927	.922	61.0
	No	.01888	.933	.928	53.0
Active	Yes	.017515	.926	.921	57.1
	No	.01998	.928	.922	50.1
Ratio Sum **	Yes	.82766	.886	.878	1.21
	No	.92828	.955	.951	1.08
$X_i,\cdots,X_5$	Yes		.980	.970	
	No		.980	.967	
OH-58 *	Yes	.01313	.834	.822	76.2
	No	.01548	.858	.847	64.6
UH-1 *	Yes	.01061	.789	.774	94.3
	No	.0125	.845	.832	80.0
AH-1 *	Yes	.015865	.794	.779	63.0
	No	.01915	.832	.818	52.2
CH-47 *	Yes	.03603	.739	.720	27.8
	No	.0502	.837	.823	19.9
UH-60 *	Yes	.0238	.777	.762	42.0
	No	.1667	1.000	1.000	6.0

* Model is $Y_i = \beta X_i$ + error where X_i is aircraft of type i and Y_i is FMT requirement for type i.

** Model is $Y = \beta(\Sigma X_i/A_i)$ + error where X_i is as above, A_i is average aircraft per FMT of type i.

situation, in Europe a set of aircraft may have one location for organizational maintenance, another location for intermediate maintenance, and a third location for the supporting FMTs. However, note that the support ratios for Europe in Table E-1 are close to those of FORSCOM, especially to the non-Forts Bragg and Campbell ratios. Thus the models we have considered for FORSCOM are likely to be of use for USAREUR if we apply them to areas large enough to include both organizational and intermediate maintenance points. Since the USAREUR ratios are close to the restricted FORSCOM ratios and a model that predicts both specialized and total helicopter FMT requirements is desirable, we use the Ratio Sum Model with $\beta = 1$ and the restricted FORSCOM ratios. This model yields 20.7 as the total USAREUR requirement, while the actual requirement is 22.

In conclusion, the FMT requirements to support helicopters seem to be closely related to density of aircraft. The Ratio Sum model--using the FORSCOM support ratios which do not include data from Forts Bragg and Campbell--closely approximates the recognized requirements for FORSCOM and probably works as well for USAREUR. If the requirements for an air mobile or airborne unit is being estimated, it is likely that the Ratio Sum Model using only the Forts Bragg and Campbell ratios would be useful.

APPENDIX F

RELATING AVIATION REQUIREMENTS TO READINESS AND USAGE

Ideally, FMT requirements should be a function of the amount of use and the degree of current readiness of the supported equipment. Similarly, when requirements exceed FMT resources, the decision on which of the stated requirements are to be filled should depend to a considerable extent on the readiness and usage of the equipment to be supported. In this section these questions are explored using the aviation FMT requirements and fill data for FY 1981 and the readiness and flying hour data for June 1981. The locations considered are those major posts under FORSCOM, WESTCOM, and TRADOC command.

The measure of readiness to be used throughout this section is the Relative Mission Capability ratings defined as follows. Given a set of aircraft (usually all those of a specified type at a specified location) its Mission Capability (MC) rating is the ratio

$$\frac{\text{Mission Capable Hours}}{\text{Total Available Hours}}$$

Then the Relative Mission Capability (RMC) rating is the difference between the above MC rating and the corresponding MC rating for all that type of aircraft stationed at all the locations. Thus, a high RMC indicates that the specified aircraft are more ready than the average for all aircraft of that type.

These RMC ratings were computed for five types of aircraft (AH-1, CH-47, OH-58, UH-1, and UH-60) at 17 FORSCOM, WESTCOM and TRADOC posts. Stretching standard geographic boundaries somewhat, these posts will all be considered North American. During the FY 1981 base year, the UH-60s were deployed at only a few of these posts and even these deployments were sometimes switched from place to place. Consequently, it was decided to not use the UH-60 in this section of the study.

The first issue examined is the relation between the FMT requirements and fills on the one hand and aircraft readiness on the other hand. There are at least two logical views of this relation. One such view is that FMT assistance is a major determinant of aviation readiness and thus that high RMCs should correspond to FMT requirement fills and low RMCs should correspond to having zero or unfilled requirements. The second possible view is that FMT assistance is only one of many factors in determining readiness. Other such factors include command emphasis, troop training, equipment usage, and operating environment. With this view, it would be reasonable to expect that high RMC ratings should correspond to zero FMT requirements and low RMC ratings should correspond to filled requirements.

The RMC ratings for each of the four types of helicopters and for the combined set of all four types are indicated in Table F-1. The data in this table is more in accordance with the second view above than with the first view. In particular, filled requirements in general seem to correspond to low RMC ratings.

The expected pattern of high, medium, and low RMC ratings corresponding respectively to zero, unfilled and filled requirements is evident in the FORSCOM/WESTCOM data from Table F-1. From this data the need to fill the OH-58 requirements seems greater than the need to fill the UH-1 requirement.

Note the data in Table F-1 listed under the TRADOC label includes all the four aircraft types deployed at TRADOC installations independent of the command to which the aircraft are assigned. Contrary to expectation, the TRADOC installation unfilled requirements have higher RMC ratings than do the zero requirements. On this basis alone one might be encouraged to eliminate many of the present unfilled requirements and to introduce new ones where RMC ratings are low. However, other factors such as density and usage are also important in determining requirements. Four of the five TRADOC zero requirements have relatively low densities and usages (flying hours) while, conversely, four of the five unfilled requirements have

TABLE F-1

RELATIVE MISSION CAPABILITY RATINGS*

REQUIREMENTS		COMBINED	FORSCOM**	TRADOC
U	NONE	-	-	-
H	UNFILLED	10.65	7.11	12.82
1	FILLED	-1.40	-1.52	-.35
O	NONE	.88	7.01	-4.58
H	UNFILLED	-.71	-4.09	8.20
5	FILLED	-.03	-.03	-
8				
A	NONE	-	-	-
H	UNFILLED	3.00	-	3.00
1	FILLED	-.04	.12	-6.90
C	NONE	1.89	-.39	2.66
H	UNFILLED	-	-	-
4	FILLED	-.28	-1.11	6.84
7				
A	NONE	6.47	11.51	.97
L	UNFILLED	8.13	4.73	12.81
L	FILLED	-1.57	-1.68	-.06

*The Relative Mission Capable rating is the difference between the rating at the given location and the rating for that aircraft at all locations.

**Also includes WESTCOM

high densities and usages. However, on the basis of the RMC ratings as well as the densities and usage rates, one would expect the Fort Eustis AH-1 support requirement to be eliminated and a new OH-58 requirement to be instituted at Fort Bliss. Ironically, such a change would result in a slightly higher disparity between the RMC ratings at zero and unfilled requirement locations.

Notice that the above discussion related RMC ratings (and usage to a minor extent) with the requirements classifications of zero, filled and unfilled. The amount of requirements was not considered, only whether the requirement existed and, if so, whether it was filled. The next question is whether the actual quantity of a requirement can be predicted from the RMC ratings and a usage factor--the monthly number of flying hours.

It is widely accepted that the quantity of flying time is a most important determinant of the aviation maintenance time and efforts. Thus a model for aviation FMT requirements should consider flying time F. Three such models will be considered:

(1) $Y = \delta \cdot F^{\alpha} \cdot \beta^{X} \cdot E$

(2) $Y = \delta \cdot F^{\alpha} \cdot E$ (i.e. $\beta = 1$)

(3) $Y = \delta \cdot F \cdot \beta^{X} \cdot E$ (i.e. $\alpha = 1$)

Where Y is the FMT man-years requirement, F is the flying hours per month, X is the RMC rating and E is a multiplicative normal noise factor, i.e., log E is a normal variable with mean zero.

The usual method of applying regression analysis to the above type of model is to first apply a logarithmic transformation and then apply standard linear regression techniques on the model with dependent variable log Y. Since the logarithm of zero is undefined, this method has problems when Y has some zero values.

There are three possible interpretations of zero requirements and each leads to a computational solution of the zero data. First, such zero requirements may be viewed as true zero requirements, i.e., no FMT activities are needed. Since logarithmic methods cannot be applied to such zeros, all data with zero requirements then should be omitted (or censored) from the calculations. Second, such requirements may be viewed as actually being non-zero but so small that they are in practice considered zero. A reasonable mathematical solution in this case is to replace each zero requirement with a fixed very small one. Since most of the requirements are powers of two, the choice was made to replace each zero with $1/16 = 2^{-4}$. Third, if aircraft are stationed at a location but do not have a stated FMT requirement, it may be that the actual requirement is nontrivial but too small to justify a stated requirement. Since the smallest stated requirements are for 0.5 man-years, the zero requirements (for places actually having that aircraft) will be replaced by requirements for 0.25 man-years.

Table F-2 summarizes the results of fitting each of the three models to the data for the four aircraft FMT requirements. Note that two of the aircraft types had some zero requirements which are treated by the three methods described above. Notice that the R^2 values for models 1 and 2 are mostly close to each other. This indicates that X, the RMC rating, is not important when F, flying hours, is already in the model. The fact that R^2 is always low for model 3, shows that F should have an exponent. For the UH-1 and AH-1 the low R^2 values indicate that the models do not fit the data. For the other two aircraft, the R^2 values indicate that models 1 and 2 are marginally acceptable. However, in these cases the estimates for all the parameters (δ, α, β) seem highly dependent on the method of treating zero data. Thus, these models seem too unstable to be credible. Hence, none of the models can be considered a good fit to any of the separate aircraft FMT requirements.

TABLE F-2

SPECIALTY USAGE AND READINESS REGRESSIONS

AIRCRAFT	ZEROS	MODEL*	d	a	b	R^2
UH-1	-	1	.15016	.223	.576	.088
	-	2	.14640	.225	-	.073
	-	3	.00093	-	.648	.005
OH-58	1/16	1	.00170	.931	.295	.569
		2	.00201	.904	-	.562
		3	.00113	-	.240	.023
	1/4	1	.03251	.505	.368	.598
		2	.03732	.483	-	.581
		3	.00173	-	.083	.105
	OMIT	1	.09189	.372	.166	.592
		2	.11106	.342	-	.415
		3	.00163	-	.085	.161
AH-1	-	1	.17977	.248	.538	.356
	-	2	.13251	.298	-	.327
	-	3	.00256	-	4.973	.105
CH-47	1/16	1	.00235	1.150	.689	.492
		2	.00257	1.132	-	.490
		3	.00487	-	.908	.000
	1/4	1	.05589	.552	.751	.388
		2	.05997	.539	-	.385
		3	.00631	-	.329	.047
	OMIT	1	3.32117	-.218	.836	.266
		2	3.48442	-.227	-	.257
		3	0.00651	-	.297	.054

*Model 1 - $Y = \delta \cdot F^{\alpha} \cdot \beta^{X} \cdot E$

2 - $Y = \delta \cdot F^{\alpha} \cdot E$

3 - $Y = \delta \cdot F \cdot \beta^{X} \cdot E$

Why does each of the models relating an aviation type FMT requirement with readiness and usage fail? Perhaps one clue is that the models for AH-1 and UH-1 fit worse than models for the other helicopter types and in all cases but one the FMT requirements for AH-1 and UH-1 are identical while the flying hours and readiness data for them are quite different. These observations raise questions about the assumption that the manpower resources are distributed among the aviation specialties according to needs. An alternate hypothesis is that the total FMT manpower at each location is closely related to total needs but the distribution among the aviation type specialties is imprecise. For example, if a location has UH-1 and AH-1 requirements of 1/2 each, this may simply indicate that both UH-1 and AH-1 require FMT assistance and that one FMT will support the two systems.

To utilize the hypothesis that total FMT requirements are based on combined needs, the data will be combined as follows. F is the total number of flying hours at the location for all four types of helicopters. N is the total number of all four helicopters at the location. The relative readiness X is defined as

$$\frac{\Sigma\ (MC_i - P_i\ D_i)}{\Sigma\ D_i}$$

Where P_i is the readiness ratio (mission capable over total hours) for aircraft of type i at all the locations, MC_i and D_i are respectively the mission capable hours and the total available hours of type i aircraft at the location. Note that $MC_i - P_i\ D_i$ represents how many more hours type i aircraft are mission capable at the location than would be expected at an "average" location.

Besides the three multiplicative models used in analyzing the separate specialist FMT requirements, similar models using the density, N, were also considered. A summary of the regression results is in Table F-3. Recall that in the analysis of the separate FMT requirements, the predicted transformed values, log $\hat{Y}$, in

TABLE F-3

MULTIPLICATIVE MODELS

NORMAL LOG E	MODEL	EQUATION ESTIMATES	R^2(T)	R^2(M)	MSE(M)
YES	1	$Y = \delta F^{\alpha} \beta^{X} E$ $.00685\ F^{.797}(.3356)^{X}$	74.6%	73.6%	.7593
YES	2	$Y = \delta F^{\alpha} E$ $.00731\ F^{.786}$	73.2%	66.9%	.8908
YES	3	$Y = \delta F \beta^{X} E$ $.00160\ F(.2696)^{X}$	6.1%	72.8%	.7321
YES	4	$Y = \delta F^{\alpha} N^{\gamma} \beta^{X} E$ $.0408\ F^{.222} N^{.515}(.1542)^{X}$	81.0%	79.1%	.6478
YES	5	$Y = \delta N^{\gamma} \beta^{X} E$ $.0925\ N^{.6856}(.1232)^{X}$	80.1%	78.1%	.6306
YES	6	$Y = \delta N^{\gamma} E$ $.1060\ N^{.649}$	75.4%	66.5%	.9009
YES	7	$Y = \delta N \beta^{X} E$ $.0219\ N(.05243)^{X}$	21.4%	35.2%	1.7409

general did not fit the transformed values, log Y, and thus the models were declared unusable. Using the combined data, the transformed values log $\hat{Y}$ were a good fit to log Y and therefore two additional steps in the analysis were performed. The first step was to check how well the predicted values $\hat{Y}$ fit the original values Y. In Table F-3, $R^2(T)$ indicates the R^2 value for the transformed model--i.e.,

$$R^2(T) = 1 - \Sigma(Z-\hat{Z})^2/\Sigma(Z-\bar{Z})^2$$

where Z = log Y (log Y - log F, log Y - Log N in models (3) and (7) respectively) The goodness of fit of the original model to the original data is measured by

$$R^2(M) = 1 - \Sigma(Y-\hat{Y})^2/\Sigma(Y-\bar{Y})^2$$

where $\hat{Y}$ = antilog $\hat{Z}$ and by the mean square error

$$MSE(M) = \Sigma(Y-\hat{Y})^2/df$$

where df is the degrees of freedom. Thus a high value of $R^2(T)$ indicates that $\hat{Z} = \log \hat{Y}$ fits log Y and a high value of $R^2(M)$ or a low value of MSE(M) indicates that $\hat{Y}$ fits Y. When using transformed models such as Z = log Y another important consideration is that the transformed model (not the original model) is assumed to have normal residuals. Thus, the second additional analysis was to verify, as indicated in Table F-3, that each set of transformed model residuals $Z-\hat{Z}$ was indeed normally distributed.

Additive models are usually easier to use and compute than multiplicative models. The arithmetic computations are simplier since additive models do not use the exponential function needed by the multiplicative models. The regression is simplier since only the original model needs to be considered, not both the original and the log transformed models. Additive models are often easier to interpret also. For example, the additive versions of model 1 (or 3),

$$Y = \alpha F + \beta XF + \text{error}$$

can be expressed as

$$Y = \alpha F(1-\lambda X) + \text{error}$$

TABLE F-4

ADDITIVE MODELS

MODEL	EQUATION ESTIMATES	R^2(M)	MSE(M)
8	$Y = \delta F$ + error .00147 F F/680.3	67.4%	.8204
9	$Y = \delta N$ + error .0169 N N/59.1	59.2%	1.0279
10	$Y = \delta + \alpha X$ + error $= 2.59 - 4.38X$	3.2%	2.6023
11	$Y = \delta F(1-\gamma X)$ + error .00151 F - .00427XF F(1-2.83X)/662.3	77.1%	.6169
12	$Y = \delta N(1-\gamma X)$ + error .01716N-.03747XN N(1-2.18X)/58.3	65.3%	.9321

Using $R^2(M)$ as the measure of fit, Tables F-3 and F-4 show that the full multiplicative model (4) has the best fit to the data with the multiplicative model (5) involving the density N and the readiness X being a close second and the additive model (11) involving usage F and readiness X a close third. Using MSE(M) as the measure of fit, the same three models fit best, but their relative closeness of fit is reversed.

Note that N is generally a better variable to use than F since it is easier to ascertain and is more stable; the flying hours F may change by the season, by the mission, and by the priorities of the commander. Thus, in terms of variables used, model (5) is the most preferred of the "best" models. If an additive model is desired, model (11) is best. Model (12), which is additive and uses N and X instead of F and X, is also suitable.

Note that the parameter estimates for models (8) and (11) are close and those for models (9) and (12) are close. Thus, if the relative readiness is not available, using models (11) or (12) with X = 0 gives approximately the same results as using models (8) or (9). Note that model (9) is the "Total Aircraft" model considered in Appendix E. The data set used in that section differs in that it includes the UH-60 aircraft and it excludes the Panama (Fort Amador) data. The parameter estimates of model (9) and the Total Aircraft model are close as are the R^2 values.

Summary.

The regression analyses in this section leads to the following conclusions with respect to the relation of relative readiness ratings and aviation FMT requirements. First the relative readiness rating together with the fact of high density or usage is a good indicator in deciding whether aircraft of a given type at a given location will have zero, filled or unfilled FMT requirements. Second, the usage and readiness together did not seem to determine the quantity of each specialty aviation FMT requirement.

Considering stability and ease of computation of variables as well as goodness of fit, the combined aviation FMT requirements are best determined by an additive model involving density and relative readiness.

APPENDIX G

ANALYSIS OF THE BEAUCHAMP STUDY

In 1978 the LAO Chief at FORSCOM, COL Darwin Beauchamp, prepared a study on FMT requirements at FORSCOM installations. In this section, COL Beauchamp's methods and conclusions will be briefly explained and then his data will be reanalyzed and further conclusions will be drawn.

COL Beauchamp's study was never published; various drafts are in circulation. On the cover page the title is "Technique for Determination of Field Maintenance Technician Requirements - A Comparative Analysis and Presentation of Method." On the first inside page the title is given as "Analysis of Field Maintenance Technician (FMT) Requirements and Distribution in FORSCOM."

COL Beauchamp's analysis method was as follows: First, for each MSC and each type of force unit--e.g., heavy division, light airborne division, infantry brigade--he assigns a number of basic FMT units. "These equivalents are relative only to the minimal pattern of past and current assignments; and do not impute any predetermined basis of calculation." (Beauchamp, page 9; underlined as in original) These basic FMT units were then summed over all the major FORSCOM stations, as indicated in Table G-1.

Next, a set of FMT mission workload factors by station and MSC was computed as follows: First, a troop mass factor was defined as the number of battalions (or UICs) at the station. Second, a density factor was defined as the number of major weapon/equipment systems from the particular MSC deployed at the station. Third, the complexity factor was defined as the number of different types of major systems from the MSC at the station. Then these factors were normalized by dividing by the corresponding factors for the total FORSCOM forces (at these major posts). Finally, these were combined by first adding the three normalized factors and, second, normalizing again by dividing by the FORSCOM totals. Thus,

TABLE G-1

1978 FMT MANPOWER AT FORSCOM

	TACOM	ARRCOM	CECOM	MICOM	TSARCOM	TOTALS
ON HAND	30	26	73	16	53	198
BASIC UNITS	22	24	37	16	39	138
REQUIREMENTS	37	33	55	22	61	208

for each MSC, these final factors, called Mission Workload Factors, represent the proportion of total FORSCOM troop strength and MSC equipment at each location. Finally, the FMT workload equivalent is computed by multiplying the previously computed proportion by the total number of basic FMT units for the MSC at FORSCOM. For example, the ARRCOM mission workload factor at Fort Bragg is .084 and the number of ARRCOM basic FMT units at FORSCOM is 24. Thus, the ARRCOM FMT workload equivalent at Fort Bragg is .084 X 24 = 2.016.

For each MSC and FORSCOM station pair is computed a Systems Achievement Factor which represents the difference in the readiness of the MSC's equipment at the location and the prescribed readiness standards for that equipment. The final FMT requirement is then determined as follows: If the on-hand, basic units and workload equivalents agree, that common number is the requirement. If they disagree, the Systems Achievement Factor is consulted and a quantity close to the minimum of the three numbers is chosen when the Systems Achievement Factor is highly positive and a quantity close to the maximum is chosen when the Systems Achievement is highly negative.

COL Beauchamp states that the FMT on-hand quantities and stated requirements are those of 1 February 1978. He does not state the source or date of validity for his data on equipment deployment. A chart attached to his study indicates which types of equipment were counted in computing the density factor. However, there is no indication of which types of equipment were considered in computing the complexity factor.

The final recommended requirements obtained by this method were substantially below both the on-hand and the stated requirements at that time. Of course this

conclusion was inherent in the method, since the system or model basically used its computed workload factor to distribute the total number of "Basic FMT Units" among the various stations. Since the total number of Basic FMT Units chosen was substantitally less than either the on-hand or stated requirements, as indicated in Table G-1, the final recommended amounts had also to be generally substantially less.

A questionable aspect of the Beauchamp technique was its adding together the three normalized factors. This gave equal weight to each factor. To test the validity of this equal weighing procedure, the following model and submodels were considered:

(1) $Y = \delta + \alpha M + \beta D + \gamma C + E$

(2) $Y = \delta + \beta D + \gamma C + E$

(3) $Y = \delta + \beta D + E$

(4) $Y = \delta + \gamma C + E$

(5) $Y = \delta + \alpha M + E$

where

Y is the FMTs on hand

M is the relative mass

D is the relative density

C is the relative complexity

E is a normal error.

The results of fitting these models to COL Beauchamp's data is summarized in Table G-2.

Each model has 2, 3, or 4 parameters and is applied to data with n=11 sample points. Thus, each fitted model has 7.8 or 9 degrees of freedom. For these degrees of freedom, a one-sided student's t test at the 90% confidence level has critical value approximately t=1.40. Thus, a parameter with estimated value v and

TABLE G-2

MASS, DENSITY, COMPLEXITY MODELS

MSC MODEL		PARAMETER ESTIMATES * δ	α	β	γ	R^2
TACOM	1	-1.3 ± 0.9	27.1 ± 8.9	-5.2 ± 6.1	3.6 ± 1.5	.866
	2	0.2 ± 1.3	---	9.8 ± 5.2	2.7 ± 2.2	.687
	3	1.4 ± 1.4	---	14.4 ± 3.7	---	.626
	4	-.5 ± 1.5	---	---	5.6 ± 1.7	.549
	5	0.2 ± 1.1	27.5 ± 5.2	---	---	.757
ARRCOM	1	-0.1 ± 0.5	27.1 ± 5.8	0.2 ± 5.1	0.1 ± 1.1	.956
	2	1.5 ± 0.9	---	20.5 ± 5.1	-2.0 ± 2.0	.817
	3	0.9 ± 0.9	---	16.0 ± 2.7	---	.794
	4	0.1 ± 1.5	---	---	4.7 ± 1.8	.454
	5	-0.1 ± 0.4	27.5 ± 2.0	---	---	.956
CECOM	1	4.6 ± 1.7	107.9 ± 22.8	-21.1 ± 20.9	-10.3 ± 7.3	.920
	2	-2.1 ± 3.2	---	50.1 ± 27.7	5.1 ± 12.5	.665
	3	0.2 ± 3.1	---	59.7 ± 14.3	---	.658
	4	-9.1 ± 3.6	---	---	24.1 ± 7.6	.528
	5	-0.3 ± 1.8	68.7 ± 8.6	---	---	.877
MICOM	1	-0.5 ± 0.5	3.6 ± 3.9	4.2 ± 4.8	2.5 ± 1.0	.875
	2	-0.5 ± 0.5	---	6.3 ± 4.2	2.9 ± 0.9	.859
	3	-0.0 ± 0.7	---	16.5 ± 3.7	---	.683
	4	-0.5 ± 0.5	---	---	3.9 ± 0.6	.820
	5	0.2 ± 0.7	13.6 ± 3.2	---	---	.673
TSARCOM	1	-3.3 ± 1.2	9.4 ± 13.6	12.8 ± 6.6	9.7 ± 6.8	.887
	2	-4.8 ± 1.2	---	11.9 ± 6.3	13.8 ± 3.3	.879
	3	2.0 ± 2.0	---	29.6 ± 7.9	---	.612
	4	-6.2 ± 1.3	---	---	18.0 ± 2.8	.825
	5	1.2 ± 1.8	37.5 ± 8.1	---	---	.703

* v ± s indicates v is the parameter estimate and s is the standard error of the estimate.

estimated standard error s will be called respectively substantially negative, substantially positive or substantially zero if $v < -1.40s$, $v > 1.40s$, or $-1.40s \leq v \leq 1.40s$.

In the models considered, only non-negative values of the parameters are meaningful. Thus, a model should be rejected if any of its parameters are substantially negative. A model with a substantially zero parameter should be rejected in favor of the submodel which omits that parameter. Using the goodness of fit measured by R^2, it is reasonable to reject an otherwise acceptable model if another acceptable model has an R^2 value at least .100 better. For example, note from Table G-2 that only the full CECOM model has a substantially positive intercept δ. However, in this model the parameters β and γ are substantially zero. Thus, this model should be rejected in favor of the submodel (5) $Y = \delta + \alpha M + E$. Note the latter CECOM model does have δ substantially zero. Using these criteria, the acceptable models are summarized in Table G-3.

Note from Table G-3 that except for the MICOM models and one of the TSARCOM models, all the "best" models involve only the mass M--i.e., the number of battalions stationed at each location. This fact is probably due to most of the MSCs assigning one FMT per unit at a given level--e.g., one per division, one per brigade, etc. The complete equality of the TACOM and ARRCOM models reflects the fact that their assignment rules are the same--viz one FMT per brigade. Note that TSARCOM has two very different acceptable models, both having fairly low R^2 values. This may be due to the fact that there are two very different types of TSARCOM FMTs--the aviation support FMT and the ground system support FMT. In Appendix E of this study it has been shown that the aviation FMT requirements are closely related to density. Indeed the measurement of density used in COL Beauchamp's work is the number of aircraft of type AH-1, UH-1, OH-58 and CH-47. Thus, the density variable is related to the number of

TABLE G-3

BEST FORSCOM MODELS

MSC	ESTIMATED MODEL	R^2
TACOM	$Y = 27.5M + E$	.757
ARRCOM	$Y = 27.5M + E$	.956
CECOM	$Y = 68.7M + E$	.877
MICOM	$Y = 6.3D + 2.9C + E$	.859
MICOM	$Y = 3.9C + E$	.820
TSARCOM	$Y = 37.5M + E$	.703
TSARCOM	$Y = 29.6D + E$	.612

aviation FMTs. It is likely that the number of ground or troop support FMTs is most closely related to the number of troop units--i.e., to the mass M. MICOM's procedure of assigning an FMT to each battalion deploying a specific complex missile system indicates why complexity C should be closely related to MICOM requirements.

Note from Table G-2 that the three variables M, D, and C have approximately equal weight for MICOM and TSARCOM and have very unequal weights for the other MSCs. Since the FMT workload equivalent is based on equally weighing these three factors, the FMT workload equivalent should be a better indicator of requirements for MICOM and TSARCOM. This is reflected in Table G-4 which summarizes the regression analysis of the model

$$Y = \delta + \theta W + E$$

where

Y is the FMTs on hand

W is the FMT workload equivalent

E is a normal noise variable.

TABLE G-4

WORKLOAD EQUIVALENT MODEL **

MSC	PARAMETER ESTIMATES * δ	θ	R^2
TACOM	-0.5 ± 1.2	1.6 ± 0.3	.721
ARRCOM	-0.1 ± 1.1	1.1 ± 0.3	.668
CECOM	-6.3 ± 2.9	2.1 ± 0.5	.691
MICOM	-0.5 ± 0.4	1.3 ± 0.2	.871
TSARCOM	-3.5 ± 1.1	1.7 ± 0.2	.884

* $v \pm s$ indicates v is the parameter estimate and s is the standard error of the estimate.

** Model is $Y = \delta + \theta W + E$

where Y is FMTs on hand

W is FMT workload equivalent

E is normal noise variable.

APPENDIX H

STATISTICAL CONVENTIONS AND METHODS

Statistics, especially regression analyses, are frequently employed in this study. In this appendix explanations are provided of the statistical conventions and definitions utilized. Also the technical methods used in generating these results are described.

By an additive (or linear) model is meant an equation

$$Y = \delta + \alpha_1 X_1 + \cdots + \alpha_m X_m + E \qquad (1)$$

Where $X_1, \cdots, X_m$, Y are variables whose values can be measured and sampled and E is assumed to be a random normal variable with mean (or expected value) zero. E is known as an error or noise variable and in general is not directly measurable. $\alpha_1, \cdots, \alpha_m, \delta$ are unknown, but presumed fixed, quantities called parameters. In this study all unknown parameters are denoted by lower case Greek letters and their estimated values by the corresponding Latin letter, e.g., a_1 is the estimate for α_1. Given a sample

$$[X_1(i), X_2(i), \cdots, X_m(i), Y(i)] \text{ for } i = 1, \cdots, N \qquad (2)$$

the estimated parameter values are chosen so that the predicted values

$$\hat{Y}(i) = d + a_1 X_1(i) + \cdots + a_m X_m(i) \quad i = 1, \cdots, N$$

are closest to $Y(i)$, i.e., they are chosen so that the total square error $\Sigma(Y-\hat{Y})^2$ is minimal.

There are two standard measures of how well or how closely the model (1) fits the sample data (2). First is the mean square error

$$MSE = \Sigma(Y-\hat{Y})^2/DF$$

where $DF = N-1-m$ is the number of degrees of freedom. The second measure is the coefficient of determination

$$R^2 = 1 - \frac{\Sigma(Y-\hat{Y})^2}{\Sigma(Y-\bar{Y})^2} \qquad (3)$$

where $\bar{Y} = (Y(1) + \cdots + Y(N))/N$ is the (sample) mean value of Y. Since the relation

$$(4) \qquad \Sigma(Y-\bar{Y})^2 = \Sigma(Y-\hat{Y})^2 + \Sigma(\hat{Y}-\bar{Y})^2$$

is valid, an alternative formula is

$$(5) \qquad R^2 = \frac{\Sigma(\hat{Y}-\bar{Y})^2}{\Sigma(Y-\bar{Y})^2} .$$

To compensate for the automatic tendency of R^2 to approach 1 as m increases, an adjusted or standardized version of the coefficient of determination uses mean square errors and is defined as

$$R_a^2 = 1 - \frac{\Sigma(Y-\hat{Y})^2/(N-1-m)}{(Y-\bar{Y})^2/(N-1)} .$$

The Burroughs Advanced Statistical Inquiry System (BASIS) implemented on the Burroughs 6800 computer at Fort Lee produced most of the statistical calculations used in this study. BASIS's treatment of zero intercept models needs to be explained. Optionally, the regression analysis procedure can force the estimate for δ to be zero in model (1). With this option, however, the algorithm used by BASIS to calculate the coefficient of determination is changed to

$$(6) \qquad R^2 = 1 - \frac{\Sigma(Y-\hat{Y})^2}{\Sigma\, Y^2}$$

and the algorithm for R_a^2 changes similarly. When the intercept δ is forced to be zero, formulas (4) and (5) are no longer valid. In this case

$$\Sigma Y^2 = \Sigma(Y-\hat{Y})^2 + \Sigma\hat{Y}^2$$

is valid and with R^2 defined by (6) above, the formula

$$R^2 = \frac{\Sigma\hat{Y}^2}{\Sigma Y^2}$$

is valid.

When an entire set of models all have zero intercept, the BASIS modified R^2 calculations have been used directly. One such instance is in Appendix E dealing with the dependence of aviation FMT requirements on density of aircraft.

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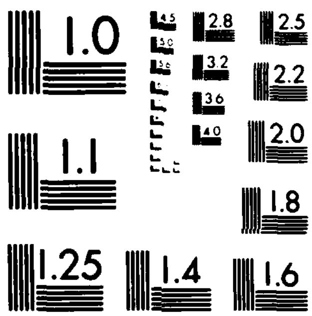

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

The rationale for using the BASIS R^2 in these cases is that all the denominators are the same and thus the R^2 values depend only on the total square error $\Sigma(Y-\hat{Y})^2$. When considering a mixed set of models, some having zero intercept, others not, the R^2 values have been recalculated when necessary so that all are computed from formula (3). An example of such mixed set of models is the set of additive and multiplicative models considered in examining the dependance of total aviation FMT requirements on relative readiness, density, and usage in Appendix F. If these R^2 values had not been recalculated, those associated with zero intercepts would have the large denominator ΣY^2 and therefore these R^2 values would all tend to be close to the value 1. Hence a cursory examination of all the R^2 values would give the misleading impression that the zero intercept models fit the data best.

APPENDIX I

AIR FORCE TECHNICAL ASSISTANCE REQUIREMENTS

The Air Force's Technical Assistance (TA) program is both more decentralized and more integrated with other logistics components than is the Army's LAP. Each Air Force MACOM runs its own program. Within the Tactical Air Command (TAC) the TA requirements are determined at meetings concerned with total logistics support of each major weapon system. For example, TAC annually schedules a logistics support meeting for the F-16 in which requirements for TA, supply, housing, etc., are all determined. The TA requirements are stated in terms of function, e.g., Air Frame, Flight Control, Propulsion Systems, Ordnance, Ground Support, Electronics. TA requirements are projected over a five-year period for budget purposes. After these TA requirements have been approved, TAC's program office hires, trains, and assigns the various technicians.

APPENDIX J

SAMPLE FORMS FOR S/DAR

A LAP System Support Plan would have two main inputs--a uniform (at least throughout a MACOM) support formula with some supporting documentation and data and particular installation equipment or unit densities and special needs with the resulting total FMT requirements. Following are sample forms that could be used for the central support plan and for the particular installation needs.

SYSTEM SUPPORT PLAN NUMBER ___

MRC: AREA: YEAR REFERENCE #

SYSTEM FIRST FIELDED LAST MODIFIED

I SUPPORT HISTORY AND PROJECTION

± YR	FY	TYPE	UNITS/FMT	PM	FSA	DRC	MACOM	COMMENTS

II SYSTEM CHARACTERISTICS

REPARABILITY	MAJOR SUBUNITS
CRITICALITY	TEST EQUIPMENT
MISSION	

FMT SKILLS	% COMMON WITH	MONTHS TRAINING (FROM LEVEL -)

III PRODUCTIVITY PROFILE (AVERAGE/FMT/MONTH)

± YR	FY	LOG REPORTS TO MRC/ETC	ASSISTS TO UNITS	O-J-T CLASSES	FORMAL CLASSES	# OF STUDENTS	HOURS TEACHING

SYSTEM INSTALLATION DENSITY AND REQUIREMENTS (SIDAR)

DATE ____________

MSC ____________

SYSTEM ____________

USAGE (HOURS/MILES) ___

STANDARD UNIT ______

A FMTs/UNIT

FY: -3	-3	-2	-1	0	1	2	3

ORGN/ LOCATION	FY	B DENSITY	C SPECIAL NEEDS (COMMENT)	AXB+C TOTAL REQUIREMENTS
	-3 -2 -1 0 1 2 3			
	-3 -2 -1 0 1 2 3			
	-3 -2 -1 0 1 2 3			
	-3 -2 -1 0 1 2 3			

APPENDIX K

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APPENDIX L

LIST OF ABBREVIATIONS AND ACRONYMS

ABN	Airborne
ACC	Air Combat Cavalry
ACR	Armored Cavalry Regiment
ADA	Air Defense Artillery
ADP	Automatic Data Processing
ADP/TF	Automatic Data Processing Equipment and TACFIRE System
ARRCOM	Armament Command
AVN or AVTN	Aviation
AVNC	Avionics
BASIS	Burroughs Advanced Statistical Inquiry System
BDE	Brigade
BN	Battalion
CBT	Combat
CECOM	US Army Communications Electronics Command
CEGE	Combat Equipment Group, Europe
CFR(S)	CHAPARREL-FARR-REDEYE-(STINGER) Systems
COMM or COMMO	Communications
CONUS	Continental United States
CSLA	Communications Security Logistics Agency
CTR	Center
DA	Department of the Army
DARCOM	US Army Materiel Development and Readiness Command
DCSLOG	Deputy Chief of Staff for Logistics
DIV	Division
DIVADS	Division Air Defense System
DLAA	DARCOM Logistics Assistance Activities
DLS	Direct Logistics Support
DLSIE	Defense Logistics Studies and Information Exchange
FMT	Field Maintenance Technician
FORSCOM	US Army Forces Command
FSA	Field Service Activity
FST	Field Supply Technician
FVS	Fighting Vehicle System
GND or GRND	Ground (Non-aviation)
GRP	Group
HQ	Headquarters
HQDA	Headquarters, Department of the Army
ILS	Integrated Logistics Support
INF	Infantry

LA	Logistics Assistance
LAO	Logistics Assistance Office
LAP	Logistics Assistance Program
LCSS	Land Combat Support System
LMS	Logistics Management Specialist
LTD	LCSS and TOW-Dragon Systems
MACOM	Major Command
MAIT	Maintenance Assistance and Instruction Team
MC	Mission Capability
MFP	Materiel Fielding Plan
MFT	Materiel Fielding Team
MICOM	US Army Missile Command
MLRS	Multiple Launch Rocket System
MMT	Missile Maintenance Technician
MN	Maintenance
MSC	Major Subordinate Command
NETT	New Equipment Training Team
OCONUS	Outside Continental United States
OR	Operational Readiness
ORD	Ordinance
ORGN	Organization
PCS	Permanent Change of Station
PM	Project Manager
POMCUS	Pre-Positional Materiel Configured to Unit Sets
RAM	Reliability, Availability, and Maintainability
RAM-D	Reliability, Availability, Maintainability - Durability
RMC	Relative Mission Capability
SIDAR	System Installation Density and Requirements
SIG/INT/EW	Signal Intelligence Electronic Warfare
SSTR	Senior Staff Technical Representative
STANO	Surveillance, Target Acquisition, and Night Observation
SUPCOM	Support Command
TA	Technical Assistance
TAC	Tactical Air Command
TACOM	US Army Tank Automotive Command
TC	TOW-Cobra
TDA	Table of Distribution and Allowances
TDY	Temporary Duty
TOW-C	TOW-Cobra System
TOW-D	TOW-Dragon System
TRADOC	US Army Training and Doctrine Command
TSARCOM	US Army Troop Support and Aviation Command
USAREUR	US Army Europe
WESTCOM	US Army Western Command

D

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